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ANNALS
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NEW SPECIES OF TERMITOPHILOUS STAPHYLINIDAE FROM TROPICAL AMERICA AND THE SOLOMON ISLANDS

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Chicago, Illinois

It has been my privilege to study a series of staphylinid beetles collected from termite colonies by Alfred E. Emerson on Barro Colorado Island, Panama Canal Zone, at Kartabo, British Guiana, and on the island of Trinidad; by Wolfgang von Hagen in Ecuador; and by Karl P. Schmidt on the Solomon Islands. I am indebted to these gentlemen for the opportunity of studying this material. The determinations of the host termites were made by A. E. Emerson.

It is my purpose to describe one new genus and a number of new species of termitophiles, to submit keys to some termitophilous genera of the Staphylinidae, and to give records of unrecorded hosts of previously described termitophiles. Notes concerning the technique of collecting termitophiles and observations on the behavior of these beetles made by Dr. Emerson at the time of collecting are also included.

Holotypes are in the collection of the author, and are eventually to be deposited in the U. S. National Museum. Paratypes are in the writer's collection and that of Alfred E. Emerson.

Before describing the species, it seems appropriate at this point to include the following notes by A. E. Emerson on the method of collecting termite guests:

"The round nests of *Nasutitermes* have proved to be the richest collecting grounds for termitophiles, but other genera also yield interesting specimens and no termites should be avoided. However, the primitive Kalotermitidae as yet, have

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yielded small returns to the collector of termitophiles. The most convenient way of bringing nests in from the field is to place the central portions into a cloth bag which has been dipped in paraffin. The top may be tied with string and termites will not escape from such a bag for several hours. If left over night, however, they usually chew holes and many will escape.

"Termitophiles may be most easily collected by bringing in the central part of the termite nest containing the royal cell and carefully knocking the termites out of the nest into a dish having vertical sides. The termites are knocked out by tapping the nest with a small hammer or pocket knife. One may then search among the termites for the termitophiles. The termitophiles seem to be more abundant near the royal cell than in the peripheral parts of the nest. Sometimes many hundreds of termitophiles may be collected in a few hours, but more often only a few specimens of each species are found.

"The behavior of the termitophiles and termites may be observed under fairly natural conditions if the dish is covered and a bit of damp cotton is placed inside to keep the humidity near the saturation point. A tight ground glass cover is the best. If the dish is small enough, one may place it under a binocular dissecting microscope and observe many of the natural actions of the termites and termitophiles."

Subfamily **Aleocharinae**

Tribe **Corotocini**

Thyreoxenus solomonensis n. sp.

(Pl. I, Figs. 1 and 2)

Length, 2.8 mm. (with abdomen recurved).

Head, sclerites of thorax, and legs (except tarsi) dark brown to black, tarsi yellow; abdominal sclerites brown; elytra and antennae pale brown; membranous portions white to light brown.

Head small, subquadrate, inserted in thorax to the middle of the eyes. Dorsal part of head with many small setae, the genae with numerous long setae projecting ventrally. Eyes occupying the anterior half of the head, partially covered by the membranous portion of the prothorax. Clypeus membranous; labrum thinly chitinized, anterior border somewhat concave. Antennae as in *T. major* Mann; basal joint elongate, slightly longer than the three following joints; second joint short, wider than long; joints 3-10 subquadrate, third joint slightly longer than any of the others; 11th joint elongate. Maxillary palpi four-jointed, first joint small, about one-fourth as long as second, second club-shaped, third joint large, cylindrical, one and one-half times as long as two,

fourth joint small, awl-shaped. Labium greatly reduced; labial palpi two-jointed, very small, second joint exceedingly minute. Examination of the labial palpi of the other species of the genus shows that they are also two-jointed, and not three-jointed as originally described.

Prothorax greatly enlarged, for the most part membranous; at widest point three times as wide as head; sides straight, not impressed. The pronotum is a chitinous plate on the anterior part of the dorsum; connected to the sternum by a dark chitinous band, the pleura. Pronotum with a narrow longitudinal incision in the median line, not extending to either border. Anterior border of pronotum strongly emarginate for some distance medially, the border within emargination arcuate; anterior angles rounded; sides converging rather rapidly posteriorly; posterior angles strongly rounded. Two, long, chitinous bars are visible posterior to the pronotum imbedded in membranous material of the prothorax. Pronotum with two transverse rows of four erect setae on the disc, and with scattered, very fine hairs.

Prothorax with a median-ventral, shallowly bilobed, membranous production beneath the head. Posterior to the chitinous prosternum is a transverse, thinly chitinized, ventrally produced lobe.

Elytra small, elongate, sides almost straight, posterior corners rounded; strongly divergent posteriorly because of pressure of the greatly swollen abdomen. Wings present as elongate, oval, membranous pads.

Legs short and stout. Anterior femora with a distinct tooth on outer, ventral border near middle. Tarsi four-jointed; first joint twice as long as the second or third, equal in length to the fourth. Coxae separated, anterior coxae very widely so.

Abdomen strongly inflated and permanently recurved; the tergites invisible from dorsal side. First abdominal segment elongate, the following ones shorter. The sternites are represented by chitinous plates on the median dorsal portion of the recurved abdomen. The chitinized areas are shown in Figures 1 and 2. Membranous areas with many erect brown setae, each setigerous puncture finely rimmed with chitin. In addition, a few setae on the sclerites proper. Between the fourth and fifth segments there is a slightly raised membranous area representing the abdominal collar which is so characteristic of *T. pulchella* Mann and *T. parviceps* Mann, but which is obsolete in *T. major*. The sternites are on the same plane with the surrounding membranous areas, and are not impressed.

T. solomonensis is most closely related to *T. major* Mann from which it differs in the following respects: (1) the arrangement of the chitinized areas of the abdomen is different; (2) each abdominal sternite is not broadly impressed posterior to the front border; and the front border of each sternite is not elevated at the middle into a rather coarse and blunt carina; (3) the presence of the blunt tooth on the front femora; (4) the sides of the prothorax (membranous part) are even, while in *major* the sides are rather strongly impressed at the middle and roundly

tuberculate in front; and (5) the abdominal collar between the 4th and 5th segments is distinct, though small, while in *major* it is obsolete.

Host: *Nasutitermes* (*Nas.*) *novarum hebridarum* (N. and K. Holmgren).

Type locality: Auki, Malaita, Solomon Islands.

Described from a unique specimen collected April 14, 1929, by Mr. Karl P. Schmidt of the Field Museum of Natural History.

The record of this new species of *Thyreoxenus* from the Solomon Islands is of considerable interest since the genus was known previously only from British Guiana, Trinidad and Panama.[1]

This wide geographic range of a genus of true termitophiles (symphiles) is very unusual in the light of what is known of the range of these genera. Previous records have shown each genus of symphile confined to one of the three main regions of termitophile distribution, namely, Africa, South America and Indo-Malaysia.

The above record, then, is the first indication of a possible close relationship between the termitophilous faunas of South America and Indo-Malaysia. This might be expected in view of the wide distribution of some of the genera of host termites, e. g., *Nasutitermes s. str.* The four species of *Thyreoxenus* are all guests of termites of the genus *Nasutitermes s. str.*

Eburniola gastrovittata n. sp.

(Pl. II, Fig. 11)

Length, 1.5 mm. (with abdomen recurved).

Chitinized portions of the body greyish brown; shining, the sides of the abdomen very strongly so. Membranous parts of the body white.

Head and pronotum sparsely and microscopically pubescent; the elytra with longer pubescence sparsely arranged on the humeri, side margins and sides. Head, pronotum and elytra without erect hairs; the first four tergites with two erect, black setae; the penultimate and apical

[1]In the material collected recently by A. E. Emerson on Barro Colorado Island, Panama Canal Zone, there are a number of specimens of *Thyreoxenus major* Mann from the nests of *Nasutitermes* (*N.*) *columbicus* (Holm.), a species of termite very closely related to the Guiana host, *N.* (*N.*) *guayanae* (Holm.). Concerning these beetles, Emerson states: ". . . They walk slowly about among the termites. Occasionally they are groomed by the termite workers. The head, antennae, thorax, legs and abdomen may be groomed without special attention being given to any part. At times the beetles were observed to jerk themselves in a manner not unlike the characteristic jerk of the termites. A beetle was once observed face to face with a termite worker and seemingly obtained a droplet from the mouth of the termite."

tergites with many finer, yellow hairs. Ventral to the apical tergite and visible through the transparent chitin, there are four chitinous cirri, the outer two each bearing two black bristles, the inner two with three bristles. The side pieces of the last segment with one bristle. The first four sternites with an apical row of six long setae and three other irregular rows of finer yellow hairs. Legs sparsely, but conspicuously setose and pubescent.

Antennae similar to those of *E. leucogaster* Mann, stout, longer than the head, pronotum, and elytra together. First joint longer than the two following joints, with the form of a cornucopia. Joints 2–10 cylindrical.

Head as wide as long; front very feebly arcuate; sides of head slightly convex, posterior angles rounded into the almost straight base. Head widest at the middle. The median line of the head shallowly impressed into a conspicuous, light-colored groove from base to front.

Pronotum slightly wider than long, nearly rectangular; sides and angles slightly rounded. Pronotum not separated from the head by a narrow membranous lobe as in many individuals of *E. leucogaster*.

Abdomen strongly inflated; the sclerites separated by rather extensive membranous areas, only the last segment completely chitinized. Dorsal and ventral sclerites of the first four segments narrow, transverse, not reaching the sides of the abdomen. The sides of abdomen with dark, irregular, chitinized areas. The ventral side of the penultimate segment not chitinized except for a narrow basal portion.

Host: Nasutitermes (*N.*) *ephratae* (Holmg.).

Type locality: Barro Colorado Island, Panama Canal Zone.

Described from a series of nineteen specimens collected by Alfred E. Emerson from one colony of termites (12, IX, 1935).

This species differs from *E. leucogaster*, the only other species of the genus, in the following respects: (1) in the much darker color of the chitinous areas; *leucogaster* being a pale yellow; (2) in the dark, chitinized areas of the sides of the abdomen, these being absent in *leucogaster*; (3) in that the ventral side of the penultimate segment is not chitinized as in *leucogaster;* (4) in the pubescence of the humeri and sides of the elytra, the elytra of *leucogaster* being glabrous; and (5) in the absence of small lobe between the head and pronotum. In many but not all, of the individuals of *E. leucogaster* there is a membranous prolongation of the prothorax between the pronotum and head.

Abroteles bisetosus n. sp.

Length, 2 mm.

Light brown in color, abdomen yellowish brown; strongly shining. Entire body (except for a wide median area of the sternites) finely and sparsely punctate, the punctures of the elytra widely separated. Head finely and sparsely pubescent; the pronotum with a very few, exceedingly short and fine, white hairs of uniform length throughout; the

elytra with sparsely arranged, semi-recumbent, long, rather stiff pubescence, considerably longer than that of the pronotum. Abdomen microscopically pubescent, except for the glabrous median area of the sternites.

Pilosity of the body as follows: pronotum with a row of six setae on the anterior border and one on each margin in front of the middle; each tergite with four on apical border; each sternite with an apical row of 16–18 setae and an additional pair midway between apical and basal borders.

Head wider than long; the front terminating in a slightly arcuate anterior border between the antennal foveae; clypeus membranous, labrum very feebly chitinized. Antennae as in *Abroteles beaumonti* Casey.

Pronotum wider than long (length : width :: 3 : 5); anterior border straight, anterior angles slightly rounded, sides diverging very slightly posteriorly; posterior angles almost rectangular, slightly rounded; posterior border pale, coriaceous. Surface of pronotum evenly convex.

Elytra almost identical in form and size to the pronotum, posterior border coriaceous, pale.

Abdomen elongated, longer than the more anterior parts together, wider than the elytra; not greatly swollen.

This species differs from *A. beaumonti* in the pubescence of the pronotum and in the pilosity of the sternites.

In *beaumonti*, the pubescence of the sides and posterior border of the pronotum is rather long and coarse, much more conspicuous than that of the disc, and equal in length to that of the elytra. In *bisetosus* the pubescence of the pronotum is exceedingly fine throughout, and much shorter than that of the elytra. The sternites of *beaumonti* have two pairs of setae (in addition to the apical row) between the basal and apical borders; the sternites of *bisetosus* have only one pair.

Host: *Nasutitermes* (*N.*) *dendrophilus* (Holmg.).

Type locality: Gualaquiza, Azuay, Ecuador.

Described from a series of forty specimens collected by Wolfgang von Hagen in one termite colony (29, X, 1934).

Casey described *A. beaumonti* as having been collected from a termite colony but he did not mention the name of the host. A number of specimens of this species were collected by Alfred E. Emerson on Barro Colorado Island in the nests of the following species of termites: 61 specimens from four colonies of *Nasutitermes* (*N.*) *corniger* Motsch.; and 67 specimens from two colonies of *Nasutitermes* (*N.*) *ephratae* (Holmg.). Emerson has the following comments to make regarding this species: "The abdomen of this beetle is held habitually over the thorax and rarely shows white between the sternites. The motion is about the same as the termite workers. It was seen being groomed by the workers. Sometimes it will hold itself sideways during the

grooming. Once it was seen cleaning its own antennae. At times this beetle was seen riding on the termites and once one was seen quietly resting on the queen termite."

Termitocola n. genus

Closely related to *Perinthus* Casey.

Head small, strongly deflexed; deeply inserted in an apical emargination of the pronotum, so that only the front and a small portion of the eyes are visible from above; wider than long, surface evenly and moderately convex. Eyes large, occupying almost the entire side of the head; finely faceted; rather densely clothed with small setae.

Antennae inserted in large foveae adjacent to the anterior margin of the eye. These foveae are located in prominent concavities of the apical portion of the front, which is vertically inclined, being almost perpendicular to the front proper. The corneus apical portion of the front strongly convex medially between the antennal insertions; not separated from the front proper by a transverse cariniform line as in *Perinthus*.

Antennae (Figure 16) eleven jointed; elongate, almost half as long as the entire body; joints slender, cylindrical, not strongly flattened as in *Perinthus*. First joint equal in length and width to terminal joint, longer and wider than any of the others. Second joint shortest, remaining joints elongate, cylindrical; last three joints gradually thicker.

Clypeus membranous; labrum short, strongly transverse, apical border slightly concave.

Mandibles small, strongly arcuate, simple, acute at tip. Mentum trapezoidal, apex narrow, truncate, basal half corneus, apical part membranous. Labial palpi three-jointed; first joint robust, second joint shorter and narrower, third joint small, acute at tip. Maxillary palpi four-jointed; first joint small; second joint triangular in outline, shorter than the third joint, which is stout, cylindrical; fourth joint about one-half the length of the third, very slender, awl-shaped.

Pronotum (Figure 20) large, strongly convex transversely; sides extending far ventrally, slightly inflexed; anterior border emarginate medially, anterior angles broadly rounded. Prosternum transverse, extremely short in front of the coxae; reaching for only a short distance posteriorly between the coxae; and with a longitudinal carina medially. The anterior coxae very large, conical, strongly convex, contiguous.

Elytra truncate, short; the anterior one-fourth covered by the pronotum, as wide as the pronotum; transversely convex, sides inclined; the epipleurae strongly inflexed, so much so that they lie almost in a transverse plane.

Mesothorax short. Scutellum invisible, completely concealed by the greatly overlapping free edge of the pronotum. Mesosternum longer than prosternum. Middle coxae large, flat, contiguous.

Hind coxae lamellate, strongly transverse, contiguous.

Abdomen, at base, slightly narrower than elytra; conical, sides convergent to the acute apex, nearly straight. Each sternite and tergite with a transverse row of erect black setae on the apical border. Upper surface of abdomen slightly convex, lower surface much more so.

Legs moderate in length; femora stout, the ventral side grooved for the partial reception of the tibia; about one-half of the hind tibiae thus concealed in repose. Tibia short, slender, cylindrical, with small terminal spurs. Tarsi four-jointed, about three-fourths as long as the tibiae; first joint of hind tarsi approximately as long as the remaining joints together.

While closely resembling the members of the genus *Perinthus* Casey, individuals of this genus differ markedly in the structure of the antennae. The very long, cylindrical antennae (Figure 16) are in sharp contrast to the short, very much flattened antennae of *Perinthus* (Figure 15). In addition, the front is not separated into apical and basal portions by a transverse cariniform line as in *Perinthus*.

Genotype: *Termitocola cylindricornis* n. sp.

Termitocola cylindricornis n. sp.

(Pl. III, Figs. 16 and 20)

Length, 2.0–2.2 mm.

Dark reddish brown, abdomen and appendages slightly lighter than the other parts; the apical half of the antennae very pale yellow. Entire body very finely and densely punctate; covered with exceedingly short, fine, dense, pale pubescence; longer on the apical borders of the abdominal segments. In addition, with long, very conspicuous, tactile setae arranged on the pronotum and elytra as in Figure 20, and on the abdomen as follows: a row of 4 near the apical border of each tergite (except the seventh, with a row of 4 and a row of 6); a row of 8 on the apical border of the first 4 sternites, 6 on the next two sternites. Terminal tergite with a conspicuous tuft of closely arranged yellow, erect hairs. Antennal joints with an apical circle of setae.

Antennae (Figure 16) elongate, 0.9 mm. long, nine-tenths as long as head, thorax and elytra together. First joint slightly shorter than joints two and three together; compressed somewhat dorso-ventrally, dorsal side with a slight concavity, so that laterally the first joint is wider than any of the other joints, dorso-ventrally it is equal in thickness to the others. Second joint short, approximately two-thirds the length of the others. Joints 3–10 elongate, cylindrical, terminal joint oval; the last three joints gradually increasing in thickness.

Host: *Nasutitermes* (*Nas.*) *pilifrons* (Holmgren).

Type locality: Barro Colorado Island, Panama Canal Zone.

Described from a series of 32 specimens collected by Alfred E. Emerson from a single colony of termites (4, V, 1935).

Perinthus hageni n. sp.

(Pl. III, Figs. 15 and 17)

Length, 1.8–2.0 mm.

Reddish brown, abdomen and appendages paler, antennae yellowish brown. Entire body minutely and very closely punctate, and clothed with an abundance of fine, short, yellow pubescence. Body with long, black tactile setae arranged as follows (Figure 17): four on pronotal margins, three transverse rows of two, four and two hairs, respectively, on the pronotal disc; two on each elytral margin and one on the elytral disc; a row of four on each tergite and six on each sternite.

Head broader than long, the front divided into two parts by a transverse cariniform line between the antennal insertions; vertex convex. Antennae (Figure 15) very similar to those of *P. dudleyanus* Casey, longer than head and pronotum, joints 4–11 strongly compressed, wider than long. The first joint equal to joints two and three together, cylindrical; terminal joint almost twice as long as the penultimate.

Pronotum two-thirds as long as broad, narrowest in front of the middle, sides convex, anterior and posterior angles broadly rounded, posterior border bisinuate. Elytra basally as wide as pronotum, sides concave at middle, posterior corners obtusely angulate. Elytra much broader than long, about two-thirds as long as the pronotum.

Hosts: *Nasutitermes* (*N.*) *ephratae* (Holmg.). Panama.
Nasutitermes (*N.*) *corniger* Motsch. Panama.
Nasutitermes (*N.*) *peruanus* form *ecuadorianus* (Holmg.) Ecuador.

Type locality: Barro Colorado Island, Panama Canal Zone.

Other locality: Hac de Tenguel, Ecuador.

Described from a series of 22 specimens collected by Alfred E. Emerson in Panama (1, IX, 35) (19, VIII, 35), and from 75 specimens collected by Wolfgang von Hagen in Ecuador (10, IX, 34).

This species is easily identified by the arrangement of the setae on the pronotum and elytra.

Emerson has the following short note concerning this beetle: "This beetle is usually seen running rapidly around among the termites which pay no special attention to it. Sometimes it may ride for a while on a termite worker."

Perinthus xenocostalis n. sp.

(Pl. III, Fig. 18)

Length, 1.6–1.9 mm.

Close to *P. dudleyanus*. Dark brown in color, elytra and pronotum darkest, appendages and abdomen lightest. Entire body finely and very closely punctate, and covered with many short, very fine, yellow hairs. Body sparsely but conspicuously setose; the long, rather coarse,

yellow hairs arranged as follows: seven on the margins of the pronotum, twelve on the disc of the pronotum as in Figure 18; two on each elytral margin and two on the disc of each elytron; a row of four at the posterior border of each tergite, and six on the apical margin of each sternite.

Head broader than long; dorsal portion of the head margined in front, the declivitous anterior portion of the front being thus separated from the posterior part; vertex slightly convex.

Antennae very similar to those of *P. hageni;* longer than head and pronotum, joints 4–11 strongly compressed, wider than long. Joint one cylindrical, equal to joints two and three together. Terminal joint about as long as the two preceding joints together.

Pronotum broad, about two-thirds as long as broad. Anterior border emarginate medially; anterior angles broadly rounded, sides slightly convex; pronotum widest behind the middle; posterior corners broadly rounded, posterior border bisinuate. Elytra basally as wide as pronotum, sides slightly concave at middle, posterior corners obtusely angulate. Elytra together much broader than long. Elytra shorter than the pronotum, the suture being approximately two-thirds the length of the pronotum.

Abdomen margined, the sides converging strongly apically.

Host: *Nasutitermes* (*Nas.*) *costalis* (Holmg.).

Type locality: St. Joseph, Trinidad (27, XI, 1920) (19, VIII, 1924).

Other locality: Kartabo, British Guiana.

Described from a series of 22 specimens collected by Alfred E. Emerson from three colonies of termites.

This species is easily distinguished by the arrangement of the setae on the pronotum and elytra.

KEY TO THE SPECIES OF PERINTHUS

(*P. crassicornis* Wasm. is not included because of the inadequate original description.)

1. Pronotum and elytra without long, tactile setae..... **silvestri** Wasm.
   Pronotum and elytra with long, tactile setae..... 2
2. Joints 4–10 of antennae longer than wide..... 3
   Joints 4–10 of antennae wider than long..... 4
3. Setae arranged: 5 on pronotal margins, 2 on elytral margins and 1 on elytral disc. Antennae longer than head and pronotum..... **tarsatus** Mann
   Setae arranged: 4 on pronotal margins and 2 on elytral margins. Antennae shorter than head and pronotum..... **vestitus** Mann
4. Setae arranged as in Figure 17..... **hageni**
   Setae arranged as in Figure 18..... **xenocostalis**
   Setae arranged as in Figure 19..... **dudleyanus**

Careful study of a large number of specimens of *Perinthus* from British Guiana, Panama and Ecuador leads me to the conclusion that *P. wasmanni* Mann is the same as *P. dudleyanus* Casey. There do not appear to be any distinguishing features.

Casey stated that *P. dudleyanus* occurred in termite colonies in Panama, but no reference was made to the host. It now

appears as if this species has a rather wide range in northern South America and occurs with a number of species of termites (polyxenous). Since the members of this genus are non-physogastric termitophiles (synoeketes)[2], we do not find the same degree of symbiotic relationship between termites and beetles that we do in the case of the physogastric termitophiles (symphiles). It seems likely that we may expect to find that only the symphiles are monoxenous.

P. dudleyanus was collected from colonies of the following termites: *Nasutitermes* (*N.*) *ephratae* (Holmg.) in British Guiana and on Barro Colorado Island, Panama; *Nasutitermes* (*N.*) *costalis* (Holmg.) in Trinidad; *Nasutitermes* (*N.*) *corniger* Motsch. on Barro Colorado Island; *Nasutitermes* (*N.*) *columbicus* (Holmg.) on Barro Colorado Island; *Nasutitermes* (*N.*) *peruanus ecuadorianus* (Holmg.) in Gualaquiza, Ecuador; *Nasutitermes* (*N.*) *dendrophilus* (Holmg.) in Gualaquiza, Ecuador.

Subfamily **Aleocharinae**

Tribe **Oxypodini**

Termitogaster impressicollis n. sp.

(Pl. II, Figs. 3 and 6)

Length, 3 mm.

Elytra, head and legs brown, abdomen reddish-brown, pronotum black. Anterior parts of the body slender, abdomen strongly inflated, the sclerites separated by white membranous areas.

Head broader than long; occiput transversely convex; vertex transversely concave. Head with a shallow, median, V-shaped impression between the antennal fossae; and with wider, shallower impressions lateral to this, behind the antennal fossae. Anterior portion of the front declivitous, shallowly impressed transversely; anterior border of the front broadly and feebly arcuate, acutely notched laterally at the termination of a groove from the antennal foveae.

Clypeus membranous; labrum in part corneus, in part membranous, anterior border almost straight. Mandibles (Figure 6) with a large median tooth, and a well-defined smaller, subapical tooth; very similar to those of *T. insolens* Casey. Antennae strongly geniculate; first joint elongate, as long as the next three joints together; second joint two-thirds as long as the third, the third joint twice as long as wide; joints four and five equal, slightly longer than wide; joints 6–10 approximately equal in length and width, eleventh joint elongate, slightly longer than nine and ten together.

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[2]Emerson states that "these beetles ran about rapidly among the termites and were seemingly never groomed by the termites. The abdomen was either held over the back or extended. Often the abdomen was perpendicular when resting. The running action was more rapid than that of the termites. Occasionally it was seen momentarily riding on the termites."

Head finely and rather densely punctate and pubescent, and with many long, fine, erect hairs on the anterior portion of the front and with three fine setae on each lateral margin of the head behind the eyes. Pronotum with two longitudinal rows of five setae on the median, depressed area of the disc, and with four setae on each side. Pilosity of the abdomen as follows: each tergite with a row of long, yellow, recumbent hairs on apical margin, two erect black hairs near apical margin, and with many finer yellow hairs; each sternite with a basal and apical row of erect black hairs, and many finer erect yellow hairs.

Pronotum (Figure 3) wider than long (width 0.46 mm., length 0.56 mm.); anterior border slightly arcuate, anterior corners rounded; sides almost parallel, slightly convex medially, posterior corners rounded. Disc of the pronotum broadly impressed on each side of the median line; the entire surface of the pronotum rather irregular in contour, with considerable individual variation in the minor impressions and ridges; usually with a rather prominent, rounded tubercle at each side of impressed disc and a median one near the posterior border as seen in the figure.

Elytra connate, shorter than the pronotum, sides straight, posterior angles acute; posterior border strongly concave, the suture of the elytra being only about three-fourths the length of the elytra at the sides.

Host: *Nasutitermes* (*Nas.*) *peruanus* form *ecuadorianus* (Holmgren).

Type locality: Hac de Tenguel, Ecuador (31, VIII, 34) (31, I, 34).

Other locality: Gualaquiza, Ecuador (1, XI, 34) (3, I, 35).

Described from a series of eleven specimens from five colonies of host termites collected by Wolfgang von Hagen.

This species is closely allied to *T. insolens* from which it is distinguished by the form of the pronotum. The pronotum of *insolens* is strongly convex and the disc is not broadly impressed as in this form. The difference is readily apparent when the specimens are viewed in profile as in Figure 3.

Termitogaster bicolor n. sp.

(Pl. II, Figs. 4 and 7)

Length, 3.0–3.25 mm.

Anterior parts of the body slender, abdomen strongly inflated. Reddish brown, elytra darker brown, pronotum black with a wide discal brown stripe. Membranous parts white.

Head broader than long (ratio 10 : 7). Front, between antennal fossae, with a rather conspicuous, longitudinal, V-shaped impression and with wider, shallower impressions posterior and lateral to this one; front indistinctly separated into anterior and posterior portions by a feeble transverse convexity, anterior portion shallowly and transversely impressed; anterior border of front broadly arcuate medially, and

acutely notched laterally at the termination of a groove from the antennal fossae.

Clypeus membranous, narrow; labrum in part corneus, and in part membranous, anterior border almost straight. Each mandible (Figure 7) with a large median tooth, and a very faint suggestion of a subapical tooth. Antennae strongly geniculate; first joint elongate (0.4 mm.), as long as head, nine-tenths as long as joints 2, 3 and 4 together. Joints two and three elongate, subequal in length, each about two and one-half times as long as broad; fourth and fifth joints equal, about two-thirds as wide as long. Joints 6–10 decreasing in length, all longer than broad; joint 11 elongate, oval. Joints 7–11 light yellowish brown, lighter than any other part of the body.

Many erect brown hairs on front (anterior to antennal fossae); one erect hair on each side of occiput. Head (except for V-shaped impression) closely and rather deeply punctate and with many very minute hairs. Pronotum with two longitudinal rows of five hairs on the light median depressed area and four erect hairs on either side. Two erect hairs on each elytron. Pilosity of the abdomen as in *T. impressicollis*.

Pronotum with a few scattered punctures on the sides, glabrous. Pronotum (Figure 4) wider than long (width 0.5 mm., length 0.6 mm.); anterior border slightly arcuate, anterior corners rounded; sides almost parallel, slightly convex medially; posterior corners rounded. Disc of pronotum impressed; contour of impressed area irregular, anteriorly raised into a rather sharp ridge, prominent in profile; impressed area with a number of grooves, pits and slight elevations, varying in different individuals. The most conspicuous and most consistent irregularities are two rather deep pits at either side of the center and a transverse groove, interrupted medially, just in front of the posterior border.

Elytra connate, shorter than the pronotum (length of elytra : length of pronotum : : 85 : 100); sides straight, posterior angles acute. Posterior border strongly concave, the suture of elytra being only about three-fourths the total length of elytra.

Legs slender, sides of femora very slightly curved.

Type locality: Gualaquiza, Azuay, Ecuador (29, X, 1934).

Host: *Nasutitermes* (*N.*) *dendrophilus* (Holmgren).

Described from a series of eleven specimens collected by Wolfgang von Hagen in two nests of host termites.

This species is most closely allied to *T. insolens* and to *T. impressicollis*. The broadly flattened, bicolored pronotum serves to distinguish it from these species. The mandibles differ from those of the other two species only in the minuteness of the subapical tooth, which is almost obsolete. In addition to these differences, the sides of the occiput have only one seta instead of three as in the others, and the antennae differ in being longer and in having the second and third joints equal.

New records of host termites of species of *Termitogaster* Casey.

The following species were described by Casey as having been collected from termite nests, but he did not mention the names of the host termites. Alfred E. Emerson recently collected these species of *Termitogaster* in the nests of termites which he determined.

Termitogaster insolens Casey[3], Barro Colorado Island, Panama.
Host: *Nasutitermes* (*N.*) *corniger* Motschulsky.
Termitogaster fissipennis Casey, Barro Colorado Island, Panama.
Host: *Nasutitermes* (*N.*) *corniger* Motschulsky.

KEY TO THE SPECIES OF TERMITOGASTER

1. Elytra widely separated for almost their entire length; front of the head with two, approximate, cariniform tubercles medially 7
   Elytra connate, posterior border deeply concave; front not tuberculate 2
2. Antennae not geniculate; first joint as long as the next two joints together, **texanus** Brues
   Antennae geniculate; first joint nearly equal (or equal) to the three following joints together 3
3. Disc of pronotum broadly flattened (Figures 3 and 4), the flattened area with several deep, rounded impressions 4
   Disc of pronotum convex (Figure 5), not flattened, but with shallow, rounded impressions; pronotum uniform black 5
4. Pronotum bicolored (disc brown, sides black); joints two and three of the antennae equal, each two and one-half times as long as broad ..... **bicolor**
   Pronotum black; second joint of antennae two-thirds as long as the third, third joint twice as long as wide ..... **impressicollis**
5. Mandibles with three fine teeth medially (Figure 8) ..... **emersoni** Mann
   Mandibles with two teeth (a median and a subapical tooth) 6
6. Anterior border of the front strongly excised; each mandible (Figure 9) with two large teeth, the median tooth larger than the subapical one ..... **brevis** Mann
   Anterior border of the front feebly concave; the mandibles (Figure 6) with a large median tooth and a small subapical tooth ..... **insolens**
7. Upper border of the posterior femora nearly straight ..... **simulans** Mann
   Upper border of the posterior femora strongly concave at the basal five-eighths, then broadly angulate behind the middle; the upper margin forming in profile a broad triangle ..... **fissipennis**

After careful comparison of specimens from British Guiana and Panama, I am of the opinion that **simopelta** Mann is the same as **T. fissipennis,** as there do not appear to be any distinguishing characters.

Termitophya emersoni n. sp.

(Pl. III, Fig. 12)

Length, 3 mm. (with abdomen straightened).

Head, thorax, elytra and appendages brown, abdomen pale brown, each dorsal segment with a darker median area. Shining. Head sparsely and irregularly punctured, intervals smooth. Pronotum apparently

[3]Emerson made the following notes about this beetle: "The abdomen is conspicuously physogastric in this species and is usually held extended with the dorsal side visible from above. The abdomen may be moved readily in all directions, however. Not only were the termites observed grooming this beetle, but the beetles were occasionally seen grooming the termites. The dark pronotum and the lighter colored abdomen resembled the dark head and lighter abdomen of the soldier termites."

impunctate, but actually very minutely punctate. Elytra coarsely and irregularly punctate.

Head without erect, black hairs but with conspicuous, semi-recumbent white pubescence; longest on the sides of head behind the eyes. Pronotum with three erect hairs on each lateral margin, and with a few scattered, microscopic white hairs. Each elytron with one erect black hair and with finer white hairs sparsely but conspicuously arranged over entire surface.

Abdominal tergites 1–5 with six coarse, recumbent hairs, arranged one at the middle of each lateral margin and four at apical margin. Sixth tergite with one hair at each lateral margin; the seventh with a subapical row of four and apical row of six prominent hairs; and the terminal tergite with six long hairs apically. In addition, the tergites with many, less prominent, recumbent hairs arranged in transverse rows.

Sternites with several transverse rows of coarse, erect hairs. The first with a basal row of 3, a sub-basal row of 2, a middle row of 6, and apical row of 16–18 hairs; and with many finer recumbent and suberect hairs over entire surface. Sternites 2–4 with a basal row of 4, a middle row of 6 and an apical row of 16 hairs; and, in addition, many semi-erect fine hairs on the sides. Second and third sternites with a wide, glabrous area medially.

Head broader than long; occipital border broadly arcuate. Anterior border of front almost straight, slightly convex. Antennae (Figure 12) longer than head and pronotum together. First joint wider than any of the others (width of 1st : width of 2nd : : 10 : 7.7); nine-tenths as long as two and three together. Second joint shorter than joints 3, 4 or 5, equal to 6; as wide as long. Third and fourth joints approximately equal in length; three-fourths as wide as long. Fifth joint slightly shorter, longer than wide. Joints 6–10 approximately equal in width and length. Eleventh joint elongate, rounded at the tip.

Pronotum wider than long, width 0.52 mm., length 0.46 mm. Anterior border of pronotum straight, anterior angles rounded, sides slightly convex, posterior angles broadly rounded, posterior border arcuate. Surface of pronotum evenly convex except for a shallow impression near anterior border of disc.

Elytra at base equal in width to pronotum, at apex wider than pronotum; posterior angles broadly rounded. Posterior border of elytra emarginate, elytra separated for a short distance posteriorly. Elytra and pronotum equal in length, suture of elytra much shorter than pronotum (pronotum : elytral suture : : 10 : 7).

Femora strongly compressed, width of anterior femur 0.12 mm.

Host: *Nasutitermes* (*N.*) *ephratae* (Holmgren).

Type locality: Barro Colorado Island, Panama Canal Zone.

Other locality: Kartabo, British Guiana.

Described from a series of 21 specimens from two colonies of termites in Panama (12, IX, 35), and 6 specimens from 5 colonies in British Guiana (28, VII, 20) (6, VIII, 26), collected by Alfred E. Emerson.

The following observations were made by Dr. Emerson at the time of collecting the beetles: "These beetles move about among the termites with the same rapidity as the termite workers. The plates of the abdomen are slightly separated showing white between on the ventral side when the abdomen is raised over the thorax. The termite workers were often found grooming these beetles. Grooming of the legs is performed about as often as the grooming of the abdomen and the head was groomed once during observation of captive colonies. My impression, however, is that these beetles are groomed no more often than the workers groom each other. The beetles were often seen jerking themselves in a similar manner to the jerking of the termites. Often, although not invariably, the workers will groom the beetles following the jerking action. The beetles at times were seen to suddenly move the abdomen to one side or the other seemingly touching the tip to the workers or soldiers in the vicinity. The workers usually groomed the beetle following this action. The grooming is done with the maxillary and labial palps and possibly the hypopharynx of the worker termite and not with the mandibles. It would appear from such observations as the above that the grooming involved a response to exudates given forth from the glandular epidermis of the beetles, the secretion covering all external parts of the beetles. The jerking action would seem to be a significant social behavior possibly functioning for the dispersal of volatile substances into the air. Whatever its real function is, the jerking of the termites and beetles are so similar that one must suppose this action to be a case of convergent evolution."

Termitophya ecuadoriensis n. sp.

(Pl. III, Fig. 14)

Length, 3 mm. (with abdomen straightened).

Head, thorax, elytra and appendages dark brown, abdomen lighter brown, each dorsal segment with median darker area. Shining. Head and pronotum coarsely and irregularly punctured, elytra more sparsely punctured.

Head without erect hairs, pronotum with three black hairs on the lateral margins and each elytron with one hair. The arrangement of hairs on the abdominal tergites as in *T. emersoni;* and on the sternites as follows: first sternite with 4 irregular, transverse rows of 4, 2, 5, and 16 setae, respectively, from basal to apical margins; the second to sixth sternites with 3 rows of 5, 4, and 16 setae, respectively; terminal sternite with 12 erect setae.

Head, pronotum, and elytra with rather coarse, semi-erect, white hairs uniformly arranged. Each dorsal abdominal segment with many

fine recumbent hairs. Sternites with many fine, recumbent yellow hairs on the apical margins, and semi-erect fine black hairs over the entire surface of each sternite.

Antennae (Figure 14) longer than head and pronotum together. First joint much wider than any of the other segments (width of first joint : width of other joints : : 10 : 6); three-fourths as long as joints two and three together. Second (length : width : : 7 : 5), third (length : width : : 9 : 5), fourth (length : width : : 19 : 10), and fifth (length : width : : 8 : 5) joints elongate, slender. Joints 6–10 slightly longer than wide, eleventh joint elongate.

Head broader than long; occipital border broadly arcuate. Pronotum wider than long, width 0.54 mm., length 0.44 mm. Anterior border of pronotum straight; anterior angles rounded; sides convex, more so than in *emersoni*; posterior angles broadly rounded into slightly arcuate posterior border, surface evenly convex. Elytra and pronotum equal in length. Suture of elytra shorter than the elytra (length of suture : length of elytra : : 7 : 10).

Femora strongly compressed, width of anterior femur 0.12 mm.

Host: *Nasutitermes* (*N.*) *peruanus* form *ecuadorianus* (Holmg.)

Type locality: Gualaquiza, Ecuador (3, I, 35) (1, XI, 34).

Described from three specimens from two different colonies of termites. Collected by Wolfgang von Hagen.

Termitophya piliventris n. sp.

(Pl. III, Fig. 13)

Length, 3 mm. (with abdomen straightened).

Head, thorax and elytra dark brown; appendages and abdomen lighter. Head, pronotum, and elytra finely, densely and irregularly punctate and with fine, white pubescence. Erect black hairs arranged as follows: one above each eye on the head, three on the margin of pronotum, two on each elytron, and on the tergites as described for *T. emersoni*. The pilosity of the abdominal sternites as in *T. amica* Mann: first sternite with four transverse rows of 4, 3, 5, and 14 hairs, respectively, from basal to apical margins; second to fourth sternites with three rows of 2, 3, and 14 (or 16) hairs, respectively. In addition, the sternites with many semi-erect, finer hairs distributed over the entire surface, in which respect this species differs from *T. amica*.

Antennae (Figure 13) very similar to those of *amica*, longer than head and pronotum together, stout, joints relatively broader than those of other species except *amica* and *punctata* Mann. First joint elongate, slightly wider than other joints (width of first : width of other joints : : 10 : 8.7); as long as two and three together. Second joint (length : width : : 7 : 6), and third joint (length : width : : 7.5 : 7) slightly longer than wide; fourth joint (length : width : : 8.5 : 7) longest of all except basal and terminal joints. Joints 5–7 slightly longer than wide, 8–10 equal in length and width, terminal joint elongate, equal in length to first.

Head as in *T. amica*, wider than long, posterior border arcuate. Pronotum wider than long, width 0.65 mm., length 0.56 mm. Anterior border of pronotum straight, sides slightly convex, pronotum widest just

in front of the middle. Posterior angles rounded, posterior border almost straight.

Elytra shorter than pronotum (length of elytra : length of pronotum : : 8 : 10). Elytral suture short (length of suture : pronotum : : 62 : 100).

Femora compressed, width of anterior femur 0.16 mm.

Host: *Nasutitermes* (*N.*) *columbicus* (Holmg.).

Type locality: Barro Colorado Island, Panama Canal Zone.

Described from a series of nineteen specimens collected by Alfred E. Emerson from four colonies of termites (19, VIII, 35) (22, IV, 35).

This species is closely related to *T. amica* Mann, a guest of *Nasutitermes* (*N.*) *guayanae* (Holmg.) in British Guiana, from which it differs in the pubescence of the second and third abdominal sternites, and in the number of erect setae on the head (two in *amica*, one in this species). A wide median area of the second and third sternites is glabrous in *amica*, and has many semi-erect hairs in this species. This difference is readily apparent, especially when the abdomen is viewed from the side.

The following observations on the behavior of these beetles are by A. E. Emerson: "This beetle was a little more active than the termite workers. The abdomen was usually held over the back. White shows between the abdominal plates as it walks around. The beetle was observed jerking itself in a manner similar to that of the termites and was seen being groomed by the termites. It occasionally was seen to nudge the termites with a sidewise motion of the abdomen without response from the termites. Once a beetle was observed cleaning its own antennae."

Termitophya inornata n. sp.

Length, 3 mm. (with abdomen straightened).

Head, thorax, elytra and appendages dark brown, abdomen light brown with the median area darker. Head, pronotum, and elytra coarsely punctate, and with many fine white hairs.

Head without erect setae, pronotum with three setae on lateral margins, and each elytron with two. The pilosity of the abdominal sternites, which differs from that of the other species, is as follows: first sternite with four, irregular, transverse rows of 4, 2, 16 and 16 setae, respectively, beginning with the basal row; the following sternites with three rows of 10, 15 and 17 erect black setae. In addition, the sternites with many recumbent yellow hairs on the apical margin, and with inconspicuous, sparse pubescence on the sides only, a wide median area being glabrous.

Head broader than long, antennae as in *T. ecuadoriensis*. Pronotum

wider than long, larger than in *T. ecuadoriensis*, width 0.66 mm., length 0.54 mm. Anterior border of pronotum straight, anterior angles rounded; sides slightly convex; posterior angles rounded into an almost straight posterior border. Pronotum and elytra equal in length.

Femora broad, compressed, width of anterior femur 0.2 mm., wider than in the other species.

Host: *Nasutitermes* (*N.*) *dendrophilus* (Holmg.).

Type locality: Gualaquiza, Azuay, Ecuador.

Described from three specimens collected from a termite nest by Wolfgang von Hagen (29, X, 1934).

This species differs from *T. ecuadoriensis* in the arrangement of the setae on the sternites, the glabrous median area of the sternites, the number of setae on the elytra and in the size of the pronotum and width of the femora.

KEY TO SOME OF THE SPECIES OF TERMITOPHYA WASMANN

(*T. heyeri* Wasm., *T. wasmanni* Holmgren, and *T. holmgreni* Wasm. are not included in the key because of the very inadequate original descriptions.)

1. A wide median area of second and third sternites glabrous 2
   The entire surface of the second and third sternites with many fine, suberect hairs 5
2. Head with two setae above each eye ..... **amica**
   Head without erect setae 3
3. Each elytron with seta ..... **emersoni**
   Each elytron with two setae 4
4. Color light reddish brown, 4th antennal joint shorter than the 3rd, **flaviventris** Mann
   Color dark brown, 4th antennal joint as long as 3rd ..... **inornata**
5. Antennae (Figure 14) slender, first joint almost twice as the other joints (ratio 10 : 6); second joint longer than wide (1 : w : : 7 : 5); third and fourth joints almost twice as long as wide ..... **ecuadoriensis**
   Antennae (Figure 13) stout, first joint slightly wider than the other joints (ratio 10 : 9); second joint wider than long (1 : w : : 6 : 7); third joint (1 : w : : 7.5 : 7), and fourth joint (1 : w : : 8.5 : 7) not much longer than wide 6
6. Each elytron with two pairs of setae, and head with two setae above each eye ..... **punctata**
   Each elytron with one pair of setae, and head with one seta above each eye ..... **piliventris**

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EXPLANATION OF PLATES

PLATE I

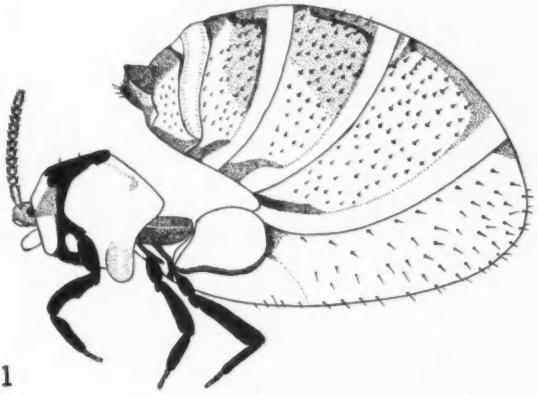
Fig. 1. *Thyreoxenus solomonensis* n. sp. Lateral view. Fig. 2. *Thyreoxenus solomonensis* n. sp. Dorsal view.

PLATE II

Fig. 3. *Termitogaster impressicollis* n. sp. Head and thorax. Fig. 4. *Termitogaster bicolor* n. sp. Head and thorax. Fig. 5. *Termitogaster insolens* Casey. Head and thorax. Fig. 6. *Termitogaster impressicollis* n. sp. and *T. insolens* Casey. Left mandible. Fig. 7. *Termitogaster bicolor* n. sp. Left mandible. Fig. 8. *Termitogaster emersoni* Mann. Right mandible. Fig. 9. *Termitogaster brevis* Mann. Right mandible; (a) dorsal view; (b) median view. Fig. 10. *Termitogaster simulans* Mann. Right mandible; (a) dorsal view; (b) median view. Fig. 11. *Eburniola gastrovittata* n. sp.

PLATE III

Fig. 12. *Termitophya emersoni* n. sp. Antenna. Fig. 13. *Termitophya piliventris* n. sp. Antenna. Fig. 14. *Termitophya ecuadoriensis* n. sp. Antenna. Fig. 15. *Perinthus hageni* n. sp. Antenna; (a) dorsal view; (b) lateral view. Fig. 16. *Termitocola cylindricornis* n. sp. Antenna; (a) dorso-lateral view; (b) dorsal view; (c) lateral view. Fig. 17. *Perinthus hageni* n. sp. Pronotum and elytra. Fig. 18. *Perinthus xenocostalis* n. sp. Pronotum and elytra. Fig. 19. *Perinthus dudleyanus* Casey. Pronotum and elytra. Fig. 20. *Termitocola cylindricornis* n. sp. Pronotum and elytra.



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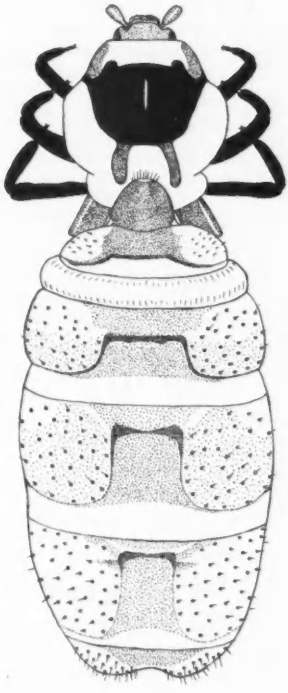

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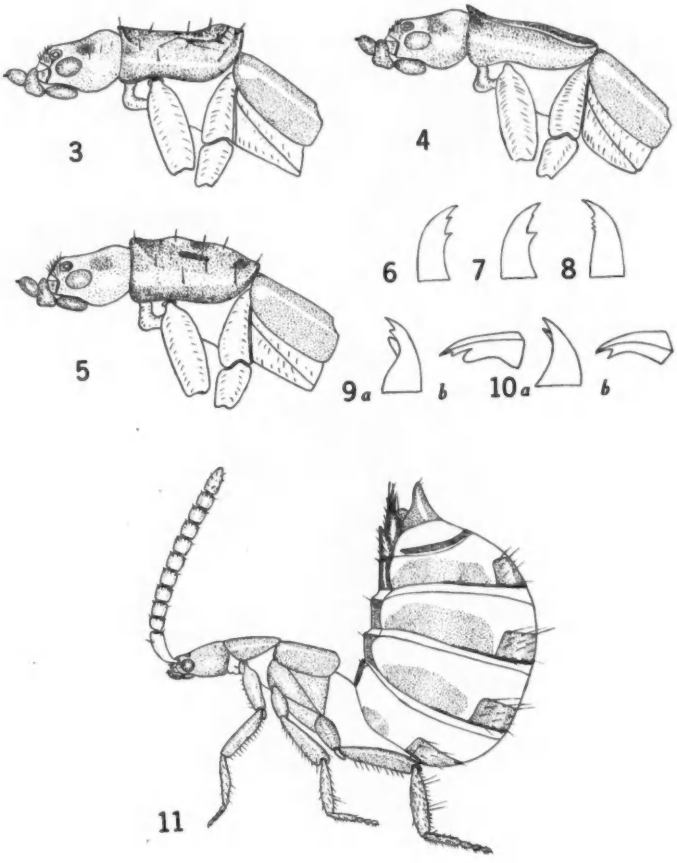
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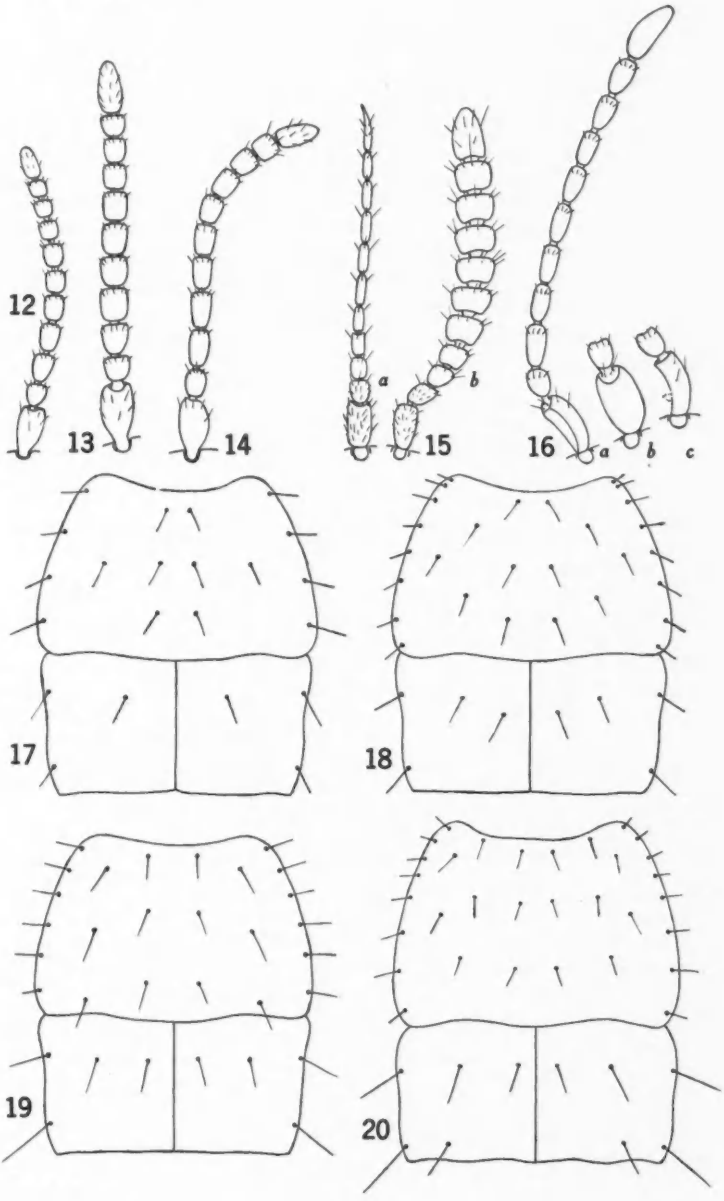
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A NEW JAPANESE PROCIPHILUS (APHIDAE)[1]

A. C. Maxson[2] and G. F. Knowlton,[3]
Utah State Agricultural College,
Logan, Utah

The following report deals with an apparently undescribed aphid of the genus *Prociphilus* from Japan. The material was received by the junior author from Dr. R. Takahashi, who, under date of April 9, 1929, wrote: "Some specimens of Japanese and Formosan aphids are being sent you, of which two species are not identified. If they are new, please describe them yourself."

Prociphilus takahashii n. sp.

Fundatrix.—The material examined contained but two stem mothers and both of these were in such poor condition that a complete description was impossible. The following partial description is based on the two available specimens:

Measurements.—Antennae: I, 0.069 to 0.087 mm.; II, 0.069 to 0.078 mm.; III, 0.191 to 0.208 mm.; IV, 0.104 mm.; V, including spur, 0.155 mm. Hind femora, 0.56 mm.; tibia, 0.54 mm.; tarsi, 0.17 mm.

Structural Characters.—Antennae 5-jointed; a permanent sensorium surrounded by cilia, at the base of the spur on V and near the distal extremity of IV. Two large wax glands on the base of the head (Fig. 1) and two smaller ones on the front; glands surrounded by chitinous rings; almost confluent at median line; four large wax glands in a transverse row on prothorax; large lateral wax glands on abdomen, their number and position undeterminable. The dorsal abdominal glands not visible in available material.

Fundatrigenia.—Color.—Color of living insect not known. Nothing distinctive about coloring of mounted specimens.

Measurements.—Length 2.14 mm. (1.91 to 2.35); hind femora, 0.64 mm. (0.55 to 0.68); tibiae, 0.81 mm. (0.63 to 0.90); tarsi, 0.20 mm. (0.16 to 0.20). Antennae 0.80 mm.; III, 0.23 mm. (0.16 to 0.28); IV, 0.13 mm. (0.10 to 0.14); V, 0.14 mm. (0.12 to 0.16); VI, 0.14 +0.04 mm. (0.11 to 0.16 + 0.02 to 0.05). Stigma, 0.17 by 0.83 mm.

Structural Characters.—Antennae 6-jointed; secondary sensoria linear or narrowly oval, not encircling joints. Sensoria on III, right, 21; left, 21 (19 to 27); IV, right, 7; left, 9 (6 to 11); V, right, 10; left 9 (8 to 12); VI, 0. Permanent and secondary sensoria surrounded by cilia; VI distinctly imbricated. Wax glands on head indistinct; not surrounded by chitinous rings; location indicated by a depression surrounded by a

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station. Publication authorized January 18, 1936.

[2]In charge of Experimental Research, Great Western Sugar Company, Longmont, Colorado.

[3]Associate Entomologist, Utah Agricultural Experiment Station.

circle of convergent fine ridges or wrinkles. Glands visible only as an irregular area of small facets; one on either side of median line of the head. Four wax pores on prothorax in a transverse row; all surrounded by chitinous rings. Lateral glands much smaller than dorsal ones; their surfaces raised, bladder-like. Glands at inner posterior margins of metathoracic lobes about equal to dorsal glands of prothorax in diameter; distance between them greater than their greatest diameter; about equal to length of II of the antenna. Abdominal wax glands present; strongly developed at lateral margins; dorsal glands, if present, not visible in available material.

Forewing with "M" simple; bases of diagonals not united; "Rs" originating slightly beyond middle of stigma and about equaling stigma in length. Hind wing with both diagonals present. Wing veins pale. Hairs on head, thorax, and legs small.

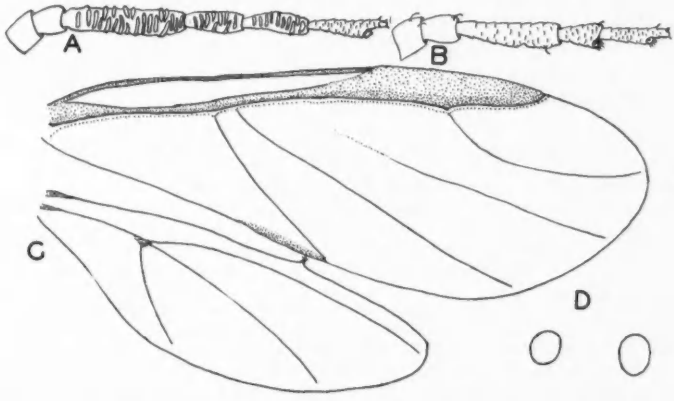

FIG. 1. *Prociphilus takahashii* n. sp. Fundatrix: *B:* antenna; *D:* a pair of thoracic wax pore plates. Fundatrigenia: *A:* antenna; *C:* wings.

Types.—Described from holotype and 40 paratypes on pear, Sapporo, Japan, July, 1921, collected by M. Hori; also collected by Dr. R. Takahashi at Yoichi, Japan, June 26, 1921, on *Pyrus*. Type slide in the U. S. National Museum. Paratypes in collections of Dr. R. Takahashi and Mr. M. Hori, of Japan, and in the collections of writers.

Taxonomy.—This species is very close to *Prociphilus corrugatus* but differs from it in not having well-defined wax glands on the head of the fundatrigenia; in having smaller, more circular wax glands on metathorax separated by a distance greater than their greatest diameter; in having "Rs" shorter in relation to the length of the stigma; in having more secondary sensoria on III to V of the antennae; and in having more secondary sensoria on V than IV.

STUDIES IN THE TIPHIIDAE (HYMENOPTERA ACULEATA)

I. A REVIEW OF THE GENERA OF MYZININAE

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It is my intention to publish under this general title a series of papers on the classification of the wasps of this family. The present paper presents a review of the genotypes of the Myzinine genera and a tentative key to the genera of the world.

Miss Grace Sandhouse of the U. S. National Museum and Mr. V. S. L. Pate and Mr. John G. Franclemont of Cornell University, have been kind enough to consult several references not available to me at the time this was written.

LIST OF GENERIC AND SUBGENERIC NAMES[1]

Braunsomeria Turner, 1912. Proc. Zool. Soc. London, p. 697. Two species.
Type: Braunsomeria quadraticeps Turner. (Original designation.)

Elis Fabricius, 1805.[2] Syst. Piezat., p. 248. Seven species.
Type: Elis sexcincta Fabricius = [*Scolia sexcincta* Fabricius, 1775 = *Myzine sexcincta* (Fabricius)]. (Designation of Bingham, 1897, Faun. Brit. Ind., Hymen., I, p. 89.)

Engycystis Fox, 1895. Proc. Calif. Acad. Sci., (2) V, p. 262.
Type: Myzine rufiventris Cresson = [*Engycystis rufiventris* (Cresson) = *Pterombrus rufiventris* (Cresson)][3]. (Monobasic.)

Hemimeria Saussure, 1892. [In Grandidier] Hist. Madagascar, XX, 1, Hymen., p. 249. Two species.
Type: Myzine Savignyi Guérin = [*Meria* (*Hemimeria*) *savignyi* (Guérin)]. (Designation of Ashmead, 1903, Canad. Entom., XXXV, p. 5.)

Huberia Ducke, 1907, nec Forel, 1890. Rev. d'Ent., XXVI, p. 5. Four species.
Type: Huberia glabricollis Ducke = [*Pterombrus glabricollis* (Ducke)[4]]. (Present designation.)

Isotiphia Ashmead, 1903. Canad. Entom., XXXV, p. 43.
Type: Isotiphia nigra Ashmead.[5] (Monobasic.)

Iswara Westwood, 1850. Trans. Ent. Soc. Lond., (2) I, p. 232.
Type: Iswara luteus Westwood. (Monobasic.)

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[1]In the citation of generic names and other relevant information I am using the format introduced by Pate in a paper on the genotypes of Sphecid wasps in a recent number of the Transactions of the American Entomological Society. The last combination of names in brackets following the citation of the genotypic species is the combination which I consider to be the correct one. The list is believed to be complete up to the end of 1935.

[2]*v.* Pate, 1935, Ent. News, XLVI, p. 267.

[3]Ducke (1907, Rev. d'Ent., XXVI, p. 145) is the authority for this synonymy.

[4]Ducke (1907, Rev. d'Ent., XXVI, p. 145) is the authority for this synonymy.

[5]I have compared the type of *Isotiphia nigra* Ashmead with the description of *Huberia clavicornis* Ducke, 1907 and believe that the two species are conspecific.

Komarowia Radoszkowski, 1886. Hor. Soc. Ent. Ross., XX, p. 41.
Type: Komarowia victoriosa Radoszkowski = [*Iswara victoriosa* (Radoszkowski)[6]]. (Monobasic.)

Macromeria S. S. Saunders, 1850. Trans. Ent. Soc. Lond., (2) I, p. 69.
Type: Meria klugii Westwood = [*Meria* (*Macromeria*) *klugii* (Westwood)]. (Monobasic.)

Magrettina Ashmead, 1901. Proc. Ent. Soc. Wash., IV, p. 144.
Type: Meria nocturna Morawitz = [*Magrettina nocturna* (Morawitz) = *Iswara nocturna* (Morawitz)[6]]. (Monobasic.)

Meria Illiger,[7] 1807. Mag. f. Insektenk., VI, p. 194.
Type: Tiphia tripunctata Rossi = [*Meria tripunctata* (Rossi)]. (Monobasic.) Isogenotypic with *Tachus* Jurine, 1807, q. v.

Meriana Rafinesque,[8] 1815. Analyse de la Nature ou Tableau de l'Universe et des corps organises (Palermo), p. 124. No species.
Type: Tiphia tripunctata Rossi = [*Meriana tripunctata* (Rossi) = *Meria tripunctata* (Rossi)]. (Present designation.) Isogenotypic with *Meria* Illiger, 1807, q. v.

Mesa Saussure, 1892. [In Grandidier] Hist. nat Madagascar, XX, 1, Hymen., p. 244. Six species.
Type: Mesa heterogamia Saussure. (Present designation.)

Micromeria Dalla Torre, 1897. Cat. Hymen., VIII, 120.
Obviously this is either a typographical error or *lapsus calami* for *Macromeria* S. S. Saunders, 1850, since Dalla Torre accredits the name to Saunders and places it under the synonymy of *Myzine* Latreille.

Milluta André, 1898. Bull. Soc. Ent. France, p. 143.
Type: Milluta chobauti André = [*Iswara chobauti* (André).[6]] (Monobasic.)

Myzina Rafinesque,[9] 1815. Analyse de la Nature ou Tableau de l'Universe et des corps organises (Palermo), p. 124. Nomen nudum.

Myzine Latreille,[10] 1803. Nouv. Dict. d'Hist. Nat., XV, p. 326.
Type: Tiphia maculata Fabricius = [*Myzine maculata* (Fabricius)]. (Monobasic.) Isogenotypic with *Myzinum* Latreille, 1803, q. v.

Myzinum Latreille,[11] 1803. Nouv. Dict. d'Hist. Nat., XV, p. 326.
Type: Tiphia maculata Fabricius = [*Myzine maculata* (Fabricius)]. (Monobasic.) Isogenotypic with *Myzine* Latreille, 1803, q. v.

Parameria Guérin, 1837. Dict. pitt. d'Hist. Nat., V, p. 575.
Type: Parameria femorata Guérin. (Monobasic.)

Plesia Jurine, 1807. Nouv. Méthod. class. Hymen., p. 152. Five species.
Type: Tiphia namea Fabricius = [*Plesia namea* (Fabricius) = *Myzine namea* (Fabricius)]. (Designation of Ashmead, 1903, Canad. Entom., XXXV, p. 5.)

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[6]Turner (1909, Ann. & Mag. Nat. Hist., (8) III, p. 476) is the authority for this synonymy.

[7]Illiger's name must be used now for the Old World species which were formerly placed in *Myzine* Latreille.

[8]Rafinesque proposed *Meriana* as an emendation or new name for *Meria* Illiger, and gave no exponents of his name, which strictly speaking thereby became isogenotypic with Illiger's name.

[9]Rafinesque accredits *Myzina* to Latreille and the name may thus be regarded as either a *lapsus calami* or typographical error for *Myzine* Latreille, 1803.

[10]Latreille gave *Myzine* as the vernacular form for *Myzinum* in his original proposal of the genus, but it was the vernacular form that Latreille adopted and used in all his subsequent publications. All other authors have followed him in this respect. Consequently, I feel that it would be best to retain this familiar orthography rather than to revert and adopt the more correct form.

[11]For a discussion of the synonymy of this genus see Pate, 1935, Ent. News, XLVI, pp. 265–267. I differ from Pate's treatment only in the minor matter of not considering *Myzine* and *Myzinum* nomenclatorially distinct.

Plesiomorpha Brèthes,[12] 1913. An. Mus. Nac. Hist. Nat. Buenos Aires, XXIV, p. 108.
Type: Plesiomorpha albinervis Brèthes. (Monobasic.)

Poecilotiphia Cameron, 1902. Journ. Bombay Nat. Hist. Soc., XIV, p. 273.
Type: Poecilotiphia albomaculata Cameron = [*Meria albomaculata* (Cameron)[13]]. (Monobasic.)

Pseudomeria S. S. Saunders, 1850. Trans. Ent. Soc. Lond., (2) I, p. 69.
Type: Parameria graeca S. S. Saunders = [*Pseudomeria graeca* (S. S. Saunders)]. (Monobasic.)

Pterombrus F. Smith, 1869. Trans. Ent. Soc. Lond., p. 302.
Type: Pterombrus aenigmaticus Smith. (Monobasic.)

Tachus Jurine, 1807. Nouv. Méthod. class. Hymen., p. 154.
Type: Tachus staphylinus Jurine, 1807 = [*Tiphia tripunctata* Rossi, 1790[14] = *Meria tripunctata* (Rossi)]. (Monobasic.) Isogenotypic with *Meria* Illiger, 1807, q. v.

In presenting the following tentative key to the genera of the subfamily Myzininae I must acknowledge my dependence in several cases on the original descriptions of the genera due to scarcity of material from the Old World. The taxonomy of the group has been in confusion for so many years that even generic identification has been almost impossible for the average worker. Saussure's[15] key is excellent in many respects but quite a few of the genera have been omitted. Ashmead's[16] key to the family Myzinidae is too full of mistakes to be of use—in several cases female characters are given under the section devoted to males, some genera are included in the group which do not belong there, and other genera belonging to the group are to be found in other families.

Nearly all the winged members of the Myzininae key down to the subfamily Tiphiinae (division M, p. 910) in Comstock's Introduction to Entomology (rev. ed., 1930) but are separated from the Tiphiinae by the fact that the antennae arise from beneath frontal lobes. The males of *Iswara* Westw. key down to the subfamily Brachycistinae (division MM, p. 911) but are immediately separated from Brachycistine males by the inner margins of the compound eyes which are deeply emarginate in *Iswara* but entire in the Brachycistinae.

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[12]I have been unable to place this genus owing to the inadequacy of Brèthes' description. It may not even belong in this subfamily.

[13]Turner (1909, Ann. & Mag. Nat. Hist., (8) III, p. 479) is the authority for this synonymy.

[14]Kohl (1882, Mitth. Schweiz. Entom. Ges., VI, p. 392) is the authority for this synonymy.

[15]Saussure, Henri de. 1892. *In* Grandidier, Histoire de Madagascar, Hymenoptera, XX, pp. 238–250.

[16]Ashmead, W. H. 1903. Canad. Entom., XXXV, pp. 4–7.

KEY TO THE GENERA OF MYZININAE

(*=Genera not seen.)

1. Females: Abdomen with six segments; antennae with twelve segments (usually only eleven are visible as the pedicel is concealed in a recess at the apex of the scape) 2
   Males: Abdomen with seven segments; antennae with thirteen segments (usually only twelve are visible) 10
2. Wings entirely absent; head quadrate and flattened; South African forms ..... ***Braunsomeria** Turner
   Wings present, although at times reduced to mere scales 3
3. Forewings often with less than three submarginal cells; when three are present the second is always petiolate and three-sided; head quadrate and flattened 4
   Forewings with three submarginal cells; the second is always sessile and four-sided; head rounded and transverse 7
4. Ocelli absent; veins forming closed cells entirely absent; wings fringed with long hairs on all edges and reduced greatly in size; nocturnal; Old World forms ..... ***Iswara** Westwood
   Ocelli present; veins forming closed cells present, at least in the forewing; wings not fringed with long hairs; diurnal 5
5. Longer spur of hind tibia straight and acute; outer margin of forewing deeply incised; Old World forms ..... **Pseudomeria** Saunders
   Longer spur of hind tibia curved; outer margin of forewing usually not deeply incised 6
6. Hind tibia globose; last joint of hind tarsus minute; Old World forms, ***Parameria** Guérin
   Hind tibia and last joint of hind tarsus normal and elongate; Old World forms ..... **Meria** Illiger
7. Pygidium glabrous and not striolate; mesonotum with parapsidal furrows only; marginal cell of the forewing confluent with the anterior margin of the wing; slender forms 8
   Pygidium opaque and longitudinally striolate; mesonotum with both notauli and parapsidal furrows present; marginal cell of the forewing removed from the anterior margin of the wing; robust forms 9
8. Antennae clavate apically; abdomen entirely black; maxillary palpi four-segmented, labial palpi three-segmented; New World forms, **Isotiphia** Ashmead
   Antennae filiform; abdomen red except for the basal segment which is black; maxillary palpi six-segmented, labial palpi four-segmented; New World forms ..... **Pterombrus** Smith
9. Longer spur of hind tibia with a pronounced tooth at the basal third; New World forms ..... **Myzine** Latreille
   Longer spur of hind tibia without a tooth at the basal third although occasionally there is a rounded lobe in this region; Old World forms, **Mesa** Saussure
10. Ocelli greatly enlarged, nearly touching the compound eyes; yellowish-brown to light castaneous in color; nocturnal forms ..... **Iswara** Westwood
    Ocelli normal in size and widely separated from the compound eyes; color usually black variegated with yellow or white, or black and red; diurnal forms 11
11. Apical third of the forewing without veins,[17] the closed cells not extending much beyond the stigma; South African forms ..... ***Braunsomeria** Turner
    Veins in the forewing usually extending quite a distance beyond the stigma 12
12. Abdominal segments red except for the first which is black. . **Pterombrus** Smith
    Abdominal segments black marked with yellow or white bands or spots, rarely the three apical segments tinged with red 13

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[17]Males of *Parameria* Guérin and *Pseudomeria* Saunders in which the females have short wings and reduced venation may key down here.

13. Anterior margin of the pronotal disc with a low, rounded transverse ridge; aedeagus slender, expanded apically into a bulb and without serrations on the ventral edge; proximal surface of inner clasper with numerous ctenidia.....**Myzine** Latreille
Anterior margin of pronotal disc with a prominent transverse lamella; aedeagus usually broadest near the base, tapering conically toward the apex and with serrations on the ventral edge; proximal surface of inner clasper without ctenidia.....14
14. First abdominal segment petiolate basally and gibbous apically when viewed from the side.....**Mesa** Saussure
First abdominal segment usually sessile basally and not gibbous apically when viewed from the side.....**Meria** Illiger

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AN INTRODUCTION TO HUMAN PARASITOLOGY, 5th Edition, by ASA C. CHANDLER. Pages i-xvi and 1-661, 308 figures. Published by JOHN WILEY & SONS, INC., 440 Fourth Ave., New York, and CHAPMAN & HALL, LTD., London. Price, $5.00.

We wish to call the attention of entomologists to this comprehensive review of the parasites of man. This is such a thorough and successful presentation of the subject for college students that it has been through five revisions in almost as many years. Though all bibliographic services class it in another branch of science, more than half of the work deals with entomological problems among which are some of the most important known to man. Except for a short term as a medical officer in the U. S. Army and three years at the School of Tropical Medicine, Calcutta, the author has been at Rice Institute, Houston, Texas, where research is highly encouraged.

The work follows a systematic plan: Part I. Protozoa, ten chapters, pp. 29–208; Part II. Helminthology, nine chapters, pp. 209–396, and Part III. Arthropods, nine chapters, pp. 397–633. The greater part of Part III deals exclusively with insect vectors. However, all through Parts I and II are extensive discussions of insect problems, the problems of insects as carriers and hosts of various protozoan and helminthid parasites.

It deals with life histories and parasite-host relationships. It handles all matter as an introduction to the subject with enough references out to open the problems up to those students who may wish to pursue some special subject farther. Famous names in the science of parasitology are introduced often enough to familiarize the beginner with the research men who have been responsible for the remarkable development of parasitology in the past thirty years. The several hundred illustrations are well chosen to give clear pictures of parasites and hosts.

The reviewer has been thrilled by this volume and recommends it to all entomologists. It is enteresting reading from cover to cover; interesting to the entomologist as it constantly reviews entomological problems in the light of what may happen to him personally when he drinks water from the wrong stream or makes careless contacts with a tropical or subtropical environment. In fact we can recommend it as a moderate palliative for that constantly recurring day dream of collecting gorgeous insects in a wonderful tropical jungle. After ten pages of it, one begins to itch in spots and to have curious internal sensations. As a radio reviewer might express it, this is a book that gets under the skin.

Needless to say it rates in sound binding and excellent workmanship with the other text books of the well known publishing house of John Wiley and Sons.

—C. H. K.

THREE NEW WESTERN SPECIES OF ERYTHRONEURA (HOMOPTERA--CICADELLIDAE)

R. H. Beamer,
Department of Entomology, University of Kansas,
Lawrence, Kansas

Erythroneura arida n. sp.

Resembling *Erythroneura davisi* Beamer but with much less brown markings throughout and with the aedeagus with processes half as long as shaft instead of slightly more than a third and with the apex of shaft in lateral view, not narrowed as in *E. davisi*.

General ground color yellowish gray, more or less clouded throughout. Vertex with two round velvety black spots either side apex, surrounded by a lighter area. Scutellum with oval velvety black spot in each basal angle. Costal plaque brighter yellow with a darker elongate mark on inner margin. Venter more or less infuscated. Anteclypeus much lighter than in *E. davisi*.

Genitalia: Pygofer prolonged and thickened on outer, upper corner with two hooks facing each other and not widely separated. Styles of the usual western type, feet smaller than in *E. davisi*. Aedeagus in lateral view long, curved dorsally, outer fourth widened with a pair of processes near apex, extending back and away from shaft for about half its length.

Holotype male, allotype female and numerous paratypes of both sexes, Belen, New Mexico, July 20, 1936, R. H. Beamer. The host was a desert bush, almost entirely leafless, and bearing a few, small purple flowers. It was found growing about a mile west of Belen.

Erythroneura cornigera n. sp.

Resembling *E. cimarroni* Beamer but much smaller, oblique markings much broader, abdomen marked with black and apical processes on aedeagus in form of antlers.

General ground color white to semihyaline tinged with yellow. Vertex with a tendency to inverted V, continued on pronotum as a pair of rounded median spots. Scutellum with basal angles and apex yellow. Tegmen with two pairs of oblique, more or less diffused, longitudinal stripes, one on clavus and one on corium. Dorsum of abdomen quite dark, venter much lighter.

Genitalia: Pygofer with but one long slender hook on dorsal margin, about half as long as pygofer. Styles of typical western form. Aedeagus large, almost as long as style, in dorsoventral view with sides almost parallel to slightly before apex where it widens and sends off two pairs of processes, one pair projecting at right angles to sides of shaft and branched at their apices. Apex of shaft broad and flattened.

Holotype male, allotype female, 15 female and 13 male paratypes, Strawberry, California, August 8, 1929, R. H. Beamer. A number of specimens of both sexes are at hand from San Jacinto Mts., Calif., that differ from this species only in having the process of aedeagus unbranched.

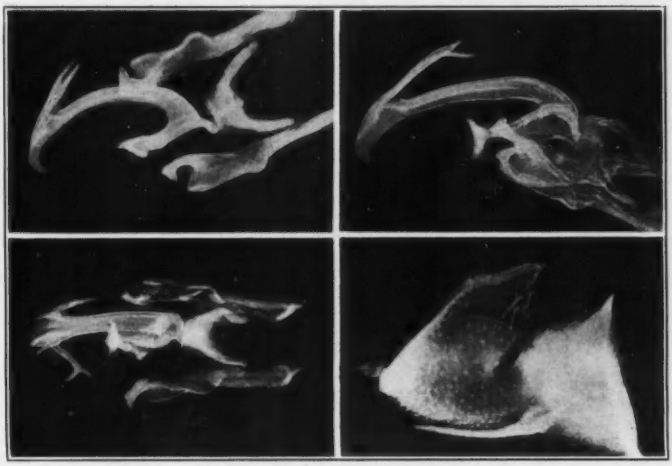
Erythroneura utahna n. sp.

Resembling *E. pinalensis* Beamer but may be separated by the tegmina being almost entirely golden yellow, by the shaft of the aedeagus in lateral view being relatively straight with two ventral processes and a tapering sharp apex, and by the outer hook of pygofer being at least twice as long as basal.

General ground color golden yellow, more or less semihyaline on tegmina. Vertex slightly more ivory at apex and narrow line at base. Pronotum with three rather indefinite spots on anterior margin and scutellum with basal two-thirds lighter. Venter yellow.

Genitalia: Pygofer with blunt basal hook less than half as long as apical, a projection on its outer margin. Apical hook sharp, about half as long as length of pygofer, slightly bent toward basal hook. Styles with typical western type of feet, rather small. Aedeagus in dorsoventral view straight tapering from base to apex with pair of recurved processes about one third distance from tip, in lateral view tapering and almost straight to outer fourth where it bends dorsally and rapidly narrows to apex, just before this bend on dorsal margin is a short, retrorse hook.

Holotype male, and one paratype male, Cedar City, Utah, August 13, 1929, R. H. Beamer, and on paratype male, Pintura. Utah, August 11, 1929.



Characters of Erythroneura.

Upper row: *E. davisi*, *E. arida*.
Lower row: *E. cornigera*, internal parts; *E. cornigera*, external parts.

THE EFFECT OF ECDYSIS ON THE NUMBER OF MITOTICALLY DIVIDING CELLS IN THE HEMOLYMPH OF THE INSECT BLATTA ORIENTALIS

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In a recent paper Tauber (7) described a method, modified slightly from that of Yeager and Tauber (10), for determining the mitotically dividing cell (M. D. C.) percentage occurring among the circulating amebocytes found in the hemolymph of normal large nymphs and adults of the roach, *Blatta orientalis*. Values of M. D. C. counts for such specimens ranged from 0.0 per cent (that is, less than one karyokinetic cell in 2,000 cells counted in each hemolymph sample) to 0.50 per cent, with an average of approximately 0.2 per cent. These values were not affected by age (within the limits indicated above), sex, or fluctuations in laboratory temperature so long as the animal remained in a condition which could be considered "normal." However, it soon became evident that the process of ecdysis was associated with decided deviations from the normal M. D. C. range. This paper is a report of results from determinations made on a series of nymphs which underwent molting during the periods of observation.

Twenty-five individuals are included in the molting series. In one case, M. D. C. counts were started five days before ecdysis occurred; with nine other roaches, the determinations were begun at least one day before molting took place. These records were possible because, to one used to observing this species, the onset of the pre-molting events can sometimes be recognized by a characteristic bloated appearance of the animal, accompanied by a general tendency to be less active than normally. The remaining fifteen specimens were removed from the stock cages either as they were undergoing ecdysis, or shortly after the process had been completed, or the next morning, if the process took place during the night. The newly molted animal can, of course, be easily recognized due to its temporary lack of pigmentation. The percentage of dividing cells in the hemolymph of this latter group was determined as soon as possible after molting.

RESULTS

Results of the M. D. C. counts from the twenty-five roaches are plotted in Figure 1 (A). The point "M" on the horizontal axis marks the day during which the exoskeleton was shed. Figures to the left of "M" represent days previous to ecdysis; to the right, after molting. Superimposed on the points in Figure 1 (A) is a composite curve connecting points representing the average M. D. C. value for each of the sixteen days during which these data were collected. Plainly evident is a tendency for the M. D. C. count to fall preceding and during molting, and as plainly marked is the tendency for a rise in M. D. C. values after shedding. The maximum point of the rise occurs usually on the third day after ecdysis. Within five days after the process is completed, the counts return to values within the normal limits. Some specimens were

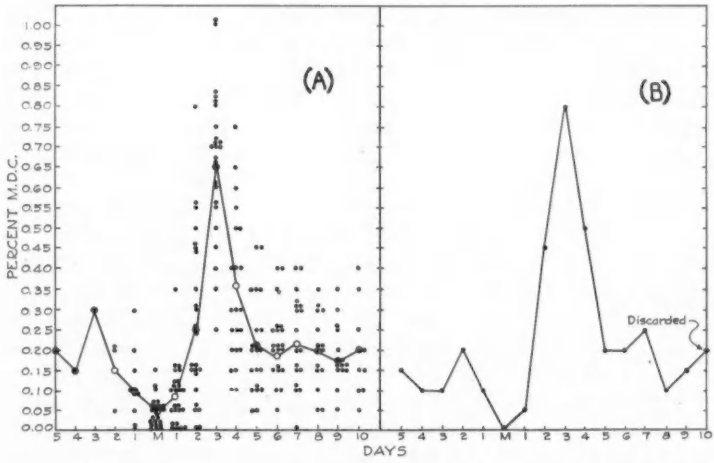

FIG. 1. Composite curve (A) and typical curve (B) from molting specimens. In (A), dots represent M.D.C. percentages collected on the indicated days. The curve connects average points based on data for those days. In (B), the curve shows the course of M.D.C. counts from animal No. 738.

kept as long as thirty-five days after molting and possessed M. D. C. percentages which remained inside the normal range of 0.0 to 0.5 per cent.

Figure 1 (B) shows a typical curve from a single molting animal, No. 738. The characteristic tendencies of the composite curve are again demonstrated here.

A summary of the data from the twenty-five specimens is given in Table I. The highest M. D. C. counts (1.0%) were encountered in animals No. 646 and No. 755. Three individuals had a maximum count of only 0.50 per cent after molting; this is just at the upper limit of the range of normal M. D. C. percentages. All others had counts higher

than the normal maximum. It should be noted that in many cases the animals were kept longer than ten days after molting. Data from counts made later than the tenth day were omitted from Figure 1 (A) since they showed nothing of significance. Most of the counts were terminated by discarding the animals; in a few cases counts had to stop due to the death of the animal from an incomplete molt.

TABLE I

SUMMARY OF DATA FROM MOLTING ROACHES

ANIMAL NUMBER	NUMBER COUNTS MADE	DAYS OBSERVED	CELLS COUNTED ($X10^3$)	MITOTIC RANGE PER CENT AFTER MOLT	EXPERIMENT TERMINATED BY
616	5	6	10	0.10–0.55	Death
634	7	9	14	0.05–0.50	Discarding
635	21	37	42	0.05–0.55	Discarding
637	18	38	36	0.05–0.60	Discarding
638	11	14	22	0.00–0.85	Discarding
639	4	4	8	0.10–0.80	Death
640	13	25	26	0.20–0.70	Discarding
641	3	3	6	0.00–0.50	Death
644	19	34	38	0.00–0.70	Discarding
646	6	6	12	0.00–1.00	Death
648	11	17	22	0.00–0.65	Discarding
650	15	27	30	0.00–0.70	Discarding
651	15	25	30	0.05–0.55	Discarding
652	17	30	34	0.00–0.80	Discarding
653	13	16	26	0.05–0.75	Discarding
654	14	24	28	0.05–0.75	Discarding
655	13	23	26	0.00–0.60	Discarding
657	11	17	22	0.00–0.50	Discarding
661	21	28	42	0.00–0.85	Death
683	17	22	34	0.00–0.65	Discarding
738	8	13	16	0.00–0.80	Discarding
739	9	12	18	0.05–0.70	Discarding
749	10	10	20	0.00–0.80	Discarding
755	11	12	22	0.05–1.00	Discarding
758	10	12	20	0.00–0.70	Discarding

DISCUSSION

An examination of the data in Figure 1 and Table I reveals that the act of molting is reflected in changes in mitotic activity of the circulating hemolymph cells. Of the twenty-five specimens included at "M" in Figure 1 (A), twelve had counts of 0.0 per cent; ten had counts of 0.05 per cent; two, 0.10 per cent; and one, 0.15 per cent. The majority of these values is within the lowest tenth of the normal M. D. C. percentage range, and all are within the lowest third of the range. After ecdysis the count tends to remain low for about a day, then begins to increase on the second day, and usually, but not always, reaches a maximum on the third day after molting. Two specimens reached counts of 1.0 per cent; four, 0.80 per cent; one, 0.75 per cent; six, 0.70 per cent; three of 0.65 per cent, which happens to be the average value for the twenty-five insects on the third day after ecdysis; and the remainder had counts of

0.55 per cent or less. A few in this latter lower group had their maximum count on the second or fourth day. In general the tendency toward a high count appears later than the second and earlier than the fourth. The values on the fourth day are definitely decreased, and only four retained or reached M. D. C. counts higher than the maximum of the normal range. On the fifth and following days all counts had come back within the limits of 0.0 to 0.50 per cent.

No certain explanation for these mitotic fluctuations which accompany shedding of the exoskeleton can be offered at the present time. It has been noted that this species ceases to eat and becomes more inactive just before ecdysis. The decrease in M. D. C. values at the same time may be associated with this general decrease of outside activities, although it is well known that the pre-molting period is one of great internal activity. In considering the rise in M. D. C. percentages after molting, there is a possible explanation other than this post-molting time is allied with a general body growth, including an increase in the number of hemolymph cells. This increase in the number of amebocytes was noted in gross observations by Tillyard (9), Landois and Landois (2), and Graber (1); and proved by actual counts by Tauber and Yeager (4, 5, 6). The other explanation is linked with the possibility that the cytolytic products from the breakdown of connective tissue before and during molting contain some protein derivative which is stimulatory to cell division, just as Reiche (3) has shown that tissue autolysates favor mitosis in various tissues. Since Taylor (8) has shown that roach amebocytes can be cultured *in vitro*, it should be possible to check this suggestion.

SUMMARY AND CONCLUSIONS

1. Percentages of mitotically dividing cells (M. D. C.) found in the circulating hemolymph of the roach, *Blatta orientalis*, were determined from twenty-five specimens undergoing ecdysis.

2. Whereas the M. D. C. range for normal animals extends from 0.0 per cent to 0.50 per cent, molting individuals may possess counts as high as 1.0 per cent a few days after shedding the old exoskeleton.

3. In general there is a decrease in the number of mitotic cells preceding and during ecdysis and an increase following molting. The maximum number of dividing cells usually appears on the third day after the skin is cast off; in a few cases the highest count was encountered on the second or fourth day. Within five days after the shedding process, the M. D. C. counts return to values within the normal range.

4. It is suggested that cytolytic products from the breakdown of tissues before and during molting may act as a stimulating agent to bring about an increase in the number of dividing cells.

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PLANT PROTECTION BY THE AID OF THERAPEUTANTS, by G. H. CUNNINGHAM, 1935. Pages i-xxvi and 1-243, with 23 figures. Published by JOHN MCINDOE, PRINTER, 76 Vogel Street, Dunedin, New Zealand. With paper cover, 15 shillings, net.

The book represents a compilation of facts taken from literature pertaining to the use of therapeutants for control of bacteria, fungi, and insects attacking plants and plant products. In places it lacks certain desired information which it seems should be included in such a volume.

The subject matter has been arranged under six sections, each section then being divided into chapters. Section I, on Sprays and Spraying, includes a discussion of the sulfur series; the polysulphide series; the arsenicals; the oils; the plant extracts, spreaders, adhesives, suspensors, and activators; spraying apparatus and methods of applying. An orchard spray schedule is included in this section. It seems that schedules for other crops would have been an excellent addition also.

Section II is on Dusts and Dusting, giving methods of application, diluents and dosages, while Section III is on phases of Fumigation and Fumigants. Section IV is on Disinfection of Seeds, Tubers, Bulbs and Corms. Section V discusses Soil Disinfection by heat methods and chemical methods.

The last Section is entitled Miscellaneous and includes fruit washing, chemically impregnated wrappers, tree surgery, tables of weights, measures, and temperatures, bibliography, and index. A glossary of terms is included in the volume.

Common names have been used throughout the book for the host plants and diseases caused by insects and fungi. Naturally much of the discussion pertains to New Zealand conditions, but nevertheless the book contains much valuable information for all economic entomologists.—R. H. D.

BIOLOGY OF THE ICHNEUMONID SPILOCRYPTUS EXTREMATIS CRESSON (HYMENOPTERA)

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In a recent study[1] of over three thousand Cecropian cocoons collected in the Chicago area in which particular attention was given to the hymenopterous parasites of Cecropia, the writer found the principal primary parasite to be *Spilocryptus extrematis Cresson*. Of all the cocoons studied, 22.8 per cent were infected with this ichneumonid. It appears to confine its activities quite largely to Cecropian larvae. The only case of infection by it, observed by the writer, other than of Cecropia was the parasitization of one larva of the saturnid moth *Telea polyphemus* Cr. Opportunity is here taken to present very briefly some of the facts in the biology of this insect which were discovered during the study.

EMERGENCE, BREEDING HABITS, AND OVIPOSITION

When the first adults emerge early in June the Cecropian larvae are barely one and one-half centimeters long. During the development of their host these ichneumonids loiter about the food plant occasionally palpating one of the larvae with their antennae, but generally ignoring them entirely and not uncommonly evincing real fear of them. More attention is usually given by the female to the excrement of the larva than to the larva itself. The writer has observed instances where the female would act over a fresh pellet much as a cat acts over catnip. The males were not observed in any such behavior.

Emergence from infected cocoons almost invariably occurs in the early morning. After gnawing a hole in its own cocoon the adult then either crawls to freedom through the valve of the host cocoon or gnaws its way through the sides. Due to a poorly developed geotropic sense in the ichneumonid larvae the pupae are not infrequently headed toward the bottom of the Cecropian cocoon. In such cases escape appears to be more difficult and adults frequently perish inside the host cocoon before they can gnaw to the outside.

S. extrematis is a nervous, alert, keen-sighted insect. The individuals appear to be rather gregarious and seem to locate each other largely by sight. If an individual is liberated in a well-lighted room in which is a sealed glass vessel containing several of its fellows the free individual will soon be walking about over the vessel. Sex appears to make no difference in this habit.

[1]Marsh, F. L., 1934. "A Regional Study of *Samia cecropia* L. and Nine Associated Parasites and Hyperparasites." A Master's thesis. Northwestern University Library, Evanston, Illinois.

Although these insects feed very eagerly on dilute honey, sugar water, or clear water, still no instance was observed in which food was taken in the natural environment. The taking of food is not necessary in the adult portion of the cycle and under laboratory conditions individuals which ate freely of dilute honey generally lived no longer than those which were given fresh water only. While the females may be active for fourteen or sixteen days, the males usually live but a few to ten or twelve days.

A female may be bred a few minutes after emerging or days later. Apparently sight brings the sexes together from a distance and then the sense of smell makes the nearby presence of the female known to the male. If the female offers no decided resistance the same male may copulate four or five times in as many minutes. Due to the confining of the wings of the female by the male the pair falls and copulation occurs on or near the ground. If other males chance to be present at such times they seem seized with a frenzy and swarm about the pair. In such cases the female is usually bred by all the males before the melèe quiets down. In one group of 15 males in the laboratory over a period of four days a single female was observed to be bred at least 65 times. Small males which cannot pinion the wings of the female are invariably brushed off with her feet.

The females which hatch early in the season die without an opportunity to oviposit. The female continually seeks for just one thing and that is a Cecropian larva which has surrounded itself with at least a thin shell of silk. Although avoiding the host larva while free living, the female ichneumonids flock around it as soon as cocoon spinning has begun. The writer has observed these insects following up wind to a new cocoon much as *Canthon* beetles follow up wind to fresh horse droppings. On one occasion thirty-four ovipositing females were counted on a single cocoon while nearly two dozen were moving about on the leaves nearby. Males were present around the edges copulating with the females that were not actually ovipositing. An egg count on this cocoon revealed 1011 ichneumon eggs. Generally, however, only as many eggs were laid as the host will support. The average number of ichneumon cocoons in a single Cecropian cocoon was thirty-three. The eggs are placed either among the fibers on the inside of the host cocoon or on the surface of the Cecropian larva. They are only slightly adhesive. In 78.5 per cent of all cases studied oviposition occurred while the larva was still spinning. In the remaining cases eggs had been laid on freshly formed pupae.

During oviposition each female thrusts the host with the lancet of her ovipositor and thus transmits a poison which not only kills the larva or pupa after a few hours but also acts to preserve it. Larvae so pierced keep their fresh green color days longer than those which have been killed in other ways.

EGG AND LARVA

The eggs are of a light yellow color and vary from a millimeter to a millimeter and a half in length. One female may lay eighteen to forty-eight eggs. In about thirty-six hours, depending on the temperature,

the larvae emerge from the ends of the eggs and leaving the delicate, skin-like egg covers behind, start in search of food. All eggs hatch whether fertilized or not. Males apparently always develop from infertile eggs. These legless, ectoparasitic larvae do not pierce the epidermis immediately but wiggle continually about over the surface of their dead host feeding on its cuticle. At the end of three or four days the larva ceases to wander about over the host and localizes in its feeding. This soon brings it to the body fluids and a rapid increase in size occurs. In five or six days maturity is reached. The average larva measures fourteen millimeters in length at this time. However, where parasitization is heavy, maturity may be reached at half this length. Considering the many eggs that are laid in the early spun host cocoons and the fact that the most ichneumon cocoons found in one host cocoon was one hundred seventy-two, and also the added fact that in no case did the writer find a larva which had failed to mature, it would seem that cannibalism among the last of the larvae must occur. In cases of heavy infestation all of the host is devoured except the few sclerotized parts.

COCOON SPINNING AND PUPATION

Some larvae were observed to begin spinning cocoons as early as four days after emerging from the egg, but the average age at spinning was about five or six days. The fairly thick-walled cocoons which are completed in forty-eight hours are spun outside the remnants of the host and inside the host cocoon. At the time of completion of the cocoon the formerly transparent skin of the larva turns to an opaque yellow.

This ichneumon is double brooded in the Chicago area. The larvae of the first brood pass into the pupa stage a few hours after completing their cocoons, and the adult emerges about eighteen days after the egg was laid.

The second brood is remarkable in that about half of them immediately come to the adult stage while the remainder, for some inexplainable reason, remain in the larval stage and continue thus through the winter, emerging any time from the first of the following June to the last of August, or in rare cases even waiting over until the second June before emerging. This irregularity of emergence quite effectively conceals the fact of double-broodedness.

In the Chicago area Cecropia is in its vulnerable stage from the middle of July to the last of August. Adults of its principal parasite are present in the field through a period extending from about three weeks before to three weeks after this stage. This fact accounts for the heavy parasitization of Cecropia by *S. extrematis*. Many of the ichneumonid females die without ovipositing. At the present time this insect is very important as a regulatory factor in the frequency of Cecropia in the Chicago area.

LIFE-HISTORY STUDIES OF THE SQUASH BEETLE IN ALABAMA

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The squash beetle (*Epilachna borealis Fab.*) is one of two species of Coccinellidae known to occur in the United States which are not carnivorous but phytophagous in nature. The squash beetle feeds upon the leaves of cucurbitaceous plants. The other species, the Mexican bean beetle (*Epilachna varivestis Muls.*), a close relative of the squash beetle, is a serious bean pest. All our other lady beetles are carnivorous, and beneficial because they feed on injurious insects, such as aphids and scale insects.

DISTRIBUTION

The squash beetle is known to occur in the following States in the United States: Alabama, Arizona, Arkansas, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, and West Virginia. It is a pest of some economic importance in sections of Connecticut, Delaware, Georgia, Maryland, New Jersey, Tennessee, and Virginia.

Outside the United States the squash beetle has been recorded by different writers from Cuba, Mexico, British Honduras, Guatemala, Nicaragua, Honduras, Costa Rica, Panama, Colombia, Brazil, and Argentina. From this it will be seen that the species probably originated in the tropics.

DESCRIPTION

The eggs are small, about three-tenths of an inch long, lemon-yellow in color, and are deposited on the under surface of the leaf (Pl. I, Fig. 1).

The larva is about one-third of an inch in length, yellow, with long, black, branching spines arranged in six longitudinal rows. Larvae feed chiefly on the under surface of the leaves (Pl. I, Fig. 1).

The pupa is lemon-yellow, about the size of the adult, and is attached to the leaf, on which it pupates by the fourth-instar larval skin, which covers the posterior abdominal segments. It is about one-third of an inch long (Pl. I, Fig. 1).

The adult is nearly hemispherical in shape, slightly oval, about one-third of an inch long, and slightly over one-fifth of an inch broad. It is of a reddish or yellowish brown color, marked on the dorsal surface with black spots, seven of which are on each wing cover and four on the prothorax (Pl. I, Fig. 1).

CHARACTER OF INJURY

Adults and larvae of the squash beetle feed voraciously on the leaves of practically all cucurbitaceous plants. The larva consumes greater quantities of leaf tissue than the adult and is therefore more destructive. Under insectary conditions the larvae feed almost entirely on the under surface of the leaf, while the adults feed mostly on the upper surface. The insects consume the epidermis and parenchyma but leave the veins and nervures almost intact. In most instances the adults have the peculiar habit of marking out circular areas with their mandibles and feeding inside of these areas. The wilting areas thus formed are apparently more palatable to the insect than the other portions of the leaf.

TABLE I

DEVELOPMENT OF FIRST AND SECOND GENERATION ADULTS OF THE SQUASH BEETLE, 1923–24

Date Eggs Deposited	Incubation Period (Days)	First Instar (Days)	Second Instar (Days)	Third Instar (Days)	Fourth Instar (Days)	Pupation Period (Days)	Date of Emergence	Developmental Period (Days)	Average Mean Temperature (F°.)
DEVELOPMENT OF FIRST-GENERATION ADULTS, 1923									
June 13	7	5	3	5	6	7	July 16	33	78
July 4	6	4	4	4	7	6	Aug. 4	31	79
July 10	6	5	4	4	8	5	Aug. 11	32	79
DEVELOPMENT OF SECOND-GENERATION ADULTS, 1923									
July 16	7	3	4	4	6	6	Aug. 15	30	78
July 19	7	4	4	4	7	6	Aug. 20	32	79
July 23	6	4	4	3	7	6	Aug. 22	30	80
July 29	7	4	4	3	7	7	Aug. 30	32	78
Aug. 7	6	3	3	6	8	7	Sept. 9	33	78
DEVELOPMENT OF FIRST-GENERATION ADULTS, 1924									
June 3	8	6	2	4	7	7	July 7	34	78
June 6	7	5	5	4	7	6	July 10	34	79
DEVELOPMENT OF SECOND-GENERATION ADULTS, 1924									
July 28	8	6	3	4	8	7	Sept. 2	36	81
July 25	8	4	5	4	10	7	Sept. 1	38	82
Aug. 2	7	4	3	7	9	8	Sept. 9	38	81

LIFE HISTORY AND DEVELOPMENT

The adult squash beetle emerges from hibernation about the middle of April, at Birmingham, Ala. Under insectary conditions some of the over-wintered adults start feeding within 24 hours after emergence from hibernation while others fly and crawl about for 10 or 15 days before

feeding. Two seasons' results in the insectary show that the average length of time between emergence from hibernation and oviposition is 50 days. The period between emergence from the pupal skin and egg deposition of the first-generation females is from 14 to 21 days. The abdomen of the female becomes noticeably enlarged for at least 24 hours before oviposition and at this time females are easily distinguished from males. Eggs are deposited on the lower surface of the leaves, in clusters of from 12 to 58. They hatch in from 6 to 8 days and the larvae molt three times before attaching themselves to pupate. When the larva pupates the larval skin slides back to the posterior end of the

TABLE II

PAIR NO. 1, OVERWINTERED PAIR

Date Eggs Deposited	Number of Eggs Deposited	Date Eggs Hatched	Number of Eggs Hatched	Percent Hatched
June 9	49	Eggs collapsed		
June 13	52	June 20	35	67.3
June 22	11	Eggs lost		
June 26	52	July 3	40	76.9
July 4	50	July 10	45	90.0
July 10	53	July 16	45	84.9
July 31	45	Eggs destroyed		
Total	312		165	64.5[1]
Average	44.5		33	

PAIR NO. 2, FIRST-GENERATION PAIR

July 16	58	July 23	40	69.0
July 19	47	July 26	15	31.9
July 23	57	July 29	35	61.4
July 26	57	Eggs destroyed		
July 29	56	Aug. 5	35	62.5
Aug. 4	45	Eggs destroyed		
Aug. 7	57	Aug. 13	30	52.6
Aug. 13	34	Eggs destroyed		
Total	411		155	56.3[1]
Average	51.3		31	

body. The larval stage lasts from 17 to 23 days, the average period being 19 days. The pupation period lasts from 5 to 8 days, depending upon the temperature. The total developmental period has been observed to last from 30 to 38 days, the average being 33 days. After the third molt the larva has attained full growth and it is in this instar that the largest amount of damage is done, for these larvae are voracious feeders and can consume a large amount of food in one day.

Complete developmental periods from egg to adult for several egg masses are given in Table I.

[1]The figures giving the percentage of eggs hatched are based upon the total number of eggs kept under observation and do not include the eggs which were lost or destroyed.

From Table 1 it will be seen that the shortest developmental period for the two seasons occurred in 1923. This was a 30-day period from July 23 to August 22. The longest developmental period occurred in 1924, a 38-day period from July 25 to September 1. In comparing the weather records of the two seasons it was seen that during the 30-day developmental period the average mean temperature was 80° F. and during the 38-day developmental period it was 82° F. The total precipitation during the 30-day period was 7.23 inches and for the 38-day period only 0.72 inch. The average mean relative humidity for the 30-day period was 82 per cent while it was only 68 per cent for the 38-day period. The extremely dry weather during 1924 increased the length of the developmental periods even though the average mean temperatures were higher than during the shorter developmental periods of 1923. From this it appears that precipitation and humidity are very important factors in determining the length of the developmental periods. It will also be seen that only two generations of *Epilachna borealis* occur in this section during a season. Newly emerged second-generation adults have been paired for two seasons but no oviposition has occurred. Adults of this generation feed, however, and a high percentage enter hibernation soon after the first frost.

Table II shows typical egg groups and records of an overwintered and a first-generation pair.

PROPORTION OF SEXES

Sex determinations were made on a number of adults reared in the insectary during 1923 and 1924. Of 130 first-generation beetles examined, 48.5 percent were males and 51.5 percent females. Of 156 second-generation beetles examined, 42.9 percent were males and 57.1 percent females. Females were produced in slightly larger numbers than males during this period. These observations are confirmed by Underhill (*5*)[2] in Virginia.

LONGEVITY

Insectary records were made on the longevity of the squash beetle. The overwintered adults from which these records were obtained hibernated in the cages in which they were kept during the winter of 1922–23. The other generations were reared from these and the length of life was thus obtained. The average length of life of overwintered males was 84 days; of females, 69 days. The average length of life of first-generation males was 62 days; of females, 79 days. Including the hibernation period, one second-generation male lived 249 days, and one second-generation female lived 334 days. Theoretically, this shows that a single generation can maintain the species in Alabama.

HABITS

Oviposition.—The eggs are deposited on the under surface of the host plant in masses of from 12 to 58. They are placed in a vertical position, one end being glued to the under surface of the leaf. The eggs

[2]Italic numbers in parentheses refer to literature cited at the end of this paper.

of a typical group are usually laid in irregular rows and closely together. It takes the female from 35 seconds to a minute to deposit an egg.

Hatching.—During mid-season when the temperature is high all eggs in a mass hatch at approximately the same time. However, early or late in the season when the temperature is low, hatching of the eggs within a mass becomes more irregular, some of the eggs hatching before others begin. In mid-season the young larvae usually travel one-fourth of an inch or more from the empty egg shells within 24 hours after hatching has begun. Early in the spring or late in the fall newly hatched larvae remain congregated on the empty eggshells for several days before scattering to feed. In most cases the young larvae do not begin feeding until 24 hours after they have hatched.

Molting.—The different stages or instars in the development of the larva are separated from one another by a molting or shedding of the larval skin. For one or two days before molting the larva stops feeding, becomes inactive, and attaches itself by its anal segment to the surface of the leaf. After a day or so the larval skin splits about half way along the dorsal surface and the new instar appears. After a molt the larva is much paler in color and very soft. The rate of growth and the size of the new adult are apparently determined to a large extent by the amount of food obtained in the larval stage. Frequently some of the larvae from a certain egg group finish molting before others begin.

Pupation.—The larva stops feeding and becomes inactive one or two days before attaching itself to pupate. It then attaches itself by its anal segment to the under surface of the leaf and remains attached for about 24 hours before pupation. At the end of this time the larval skin splits about halfway along the dorsal surface and the bright yellow pupa appears, half covered by the molted skin by which it is attached. The pupa usually hangs head downward when on a vertical surface.

Newly Emerged Adults.—When the newly emerged adult crawls out of the pupal skin it is entirely lemon-yellow in color with no spots visible. Within 20 minutes the wings become extended and the black spots appear dimly. In another 35 minutes the wings are folded beneath the elytra and the spots are distinct. The newly emerged adult does not feed until about 24 hours after it has emerged.

FOOD PLANTS

The squash beetle feeds primarily on cucurbitaceous plants although in some instances feeding has been recorded on plants not related to the cucurbits. The writer observed complete egg-to-adult development on the following plants: 1. Squash, *Cucurbita maxima* Duchesne; 2. Watermelon, *Citrullus vulgaris* Schrad; 3. Cucumber, *Cucumis sativus* L.; 4. Cantaloupe, *Cucumis melo* L.; 5. Colorado preserving citron, *Cucumis colocynthis* Schrad; 6. Bottleshaped gourd, *Langenaria vulgaris* Ser.; 7. Cushaw, *Cucurbita moschata* Duchesne.

The pairs used to determine these hosts were all newly emerged first-generation pairs from the experiments of 1923. The average length of time between emergence and oviposition was 18 days.

Adult feeding was observed on gherkin, *Cucumis anguria* L., and pumpkin, *Cucurbita pepo* L. Larval feeding was observed on a weed, *Sida spinosa* L.

F. H. Chittenden (*2, p. 13*) reports that *Epilachna borealis* readily attacks wild balsam, *Echinocystis lobata* (Michx.) T. & G., and the one-seeded bur-cucumber, *Sicyos angulatus* L.

G. W. Underhill (*5, p. 4*) observed that late in the season the beetles were seen feeding "on the blossoms, the young pods, and nectaries on the stems of lima beans and cowpeas, also on lima bean foliage and on fresh corn silk."

H. A. Gossard (*3, p. 90*) writes that *E. borealis* has been sent to him "with a lot of eaten bean pods and plants."

In 1923 the writer placed several fourth-instar *E. borealis* larvae on fresh snap bean plants for 5 days and no feeding was recorded during that time. The larvae would not remain on the plants, preferring to crawl on the sides of the wire cage.

A pair of *E. borealis* adults were placed on a fresh bean plant June 22, 1923, and closely watched for possible signs of feeding. No feeding was observed and the pair died June 28, or 6 days after the test was started. The pair appeared restless and would not remain on the plant..

In 1922, Luther Brown[3] reported slight feeding of *E. borealis* in confinement on common beans at Thomasville, Ga.

In 1924, blossoms and young pods of cowpeas and lima beans were placed in a stock cage with several adults of *E. borealis* but no signs of feeding were seen.

HIBERNATION

G. W. Underhill (*5, p. 8*) writes that the beetles spend the winter chiefly on the trunks of trees and to a less extent along fences, about old outhouses, and under leaves, trash, and rubbish. He states that they prefer to cluster in a perpendicular position and avoid horizontal locations as offered by logs, blown-over trees, etc.

W. S. Blatchley (*1, p. 532*) has observed that *E. borealis* hibernates in large colonies beneath leaves in low ground.

Neale F. Howard (*4, p. 24*) has observed *E. borealis* in hibernation beneath leaves on the ground.

The squash beetle has not been found, to the writer's knowledge, in the vicinity of Birmingham, Ala. All attempts to gather information on the hibernation of the insect were made under artificial conditions.

The species passes the winter in the adult stage. By watching the activity and recording notes on feeding it has been found that in this vicinity the beetles become sluggish during cool weather in October and practically all of them stop feeding several days before the first killing frost. This means that they usually stop feeding and seek hibernation quarters during the latter part of October.

The beetles were carried through the winter in hibernation in the insectary at Birmingham, Ala., for three seasons. Of 28 adults which went into hibernation in the fall of 1921, the emergence was 3.5 percent. Of 15 adults which went into hibernation in 1922, the emergence was

[3]Unpublished notes.

33.3 percent. In 1923 adults from the first and second generations were put separately into hibernation. Of 42 first-generation adults that went into hibernation in 1923 the emergence was 7.14 percent. Of 123 second-generation adults that went into hibernation in 1923 the emergence was 30.8 percent. The hibernation of first-generation adults given above is proof that the insect can perpetuate itself in this vicinity with one generation a season. Under artificial conditions the beetle prefers to get in crevices of the bark of the oak or pine. Very few were seen under the leaves and pine straw in the hibernation cages.

The observations on hibernation by workers previously mentioned were confirmed by the writer working in eastern Virginia during March, 1934. At this time a total of 252 squash beetles were found in hibernation near Smithfield, Va., and 585 on a farm in the vicinity of Toano, Va. At both locations the majority of the beetles were found beneath leaves and pine straw on the ground beneath oak, pine and gum trees, while others were observed in crevices of bark on the trees, Figure 2. In most instances it appeared that the beetles had first entered hibernation in crevices of bark on the tree trunks, and had apparently left these locations in large numbers during the unusually severe winter weather of 1933–34, for the better protection afforded by the leaves and pine straw beneath the trees. In all instances the beetles were found along the borders of woods nearest the location of the infested crop of the previous year.

SUMMARY

The squash beetle is an insect enemy of cucurbits and is of some economic importance in sections of States on and near the Atlantic seaboard. The States most heavily infested are Connecticut, Delaware, Georgia, Maryland, New Jersey, Tennessee, and Virginia. The female deposits lemon-yellow eggs in masses of from 12 to 58 on the under surface of the leaves of cucurbitaceous plants, and in from 6 to 8 days these hatch into small yellow larvae with long, black, branching spines. The larval period, as observed at Birmingham, Ala., is from 17 to 23 days. The larva pupates on the under surface of the leaf and emerges as a beetle in from 5 to 8 days, and the entire period required for development from egg to adult in this vicinity is from 30 to 38 days.

The larvae feed entirely on the under surface of the leaves while the adults feed mostly on the upper surface. Two generations occur annually in Alabama, but it is possible for one generation to maintain the species. The beetles have the peculiar habit of marking out feeding areas with their mandibles and feeding inside of these areas. The larva consumes greater quantities of leaf tissue and is therefore more destructive than the beetle.

Winter is passed by the beetle in crevices on the bark of trees in the woods near where cucurbits were grown the previous season, and in large colonies beneath leaves on low ground.

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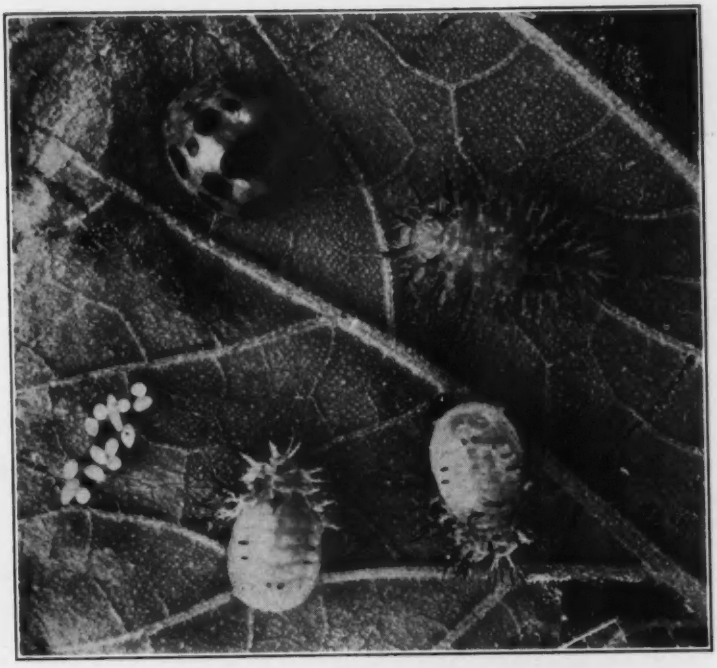
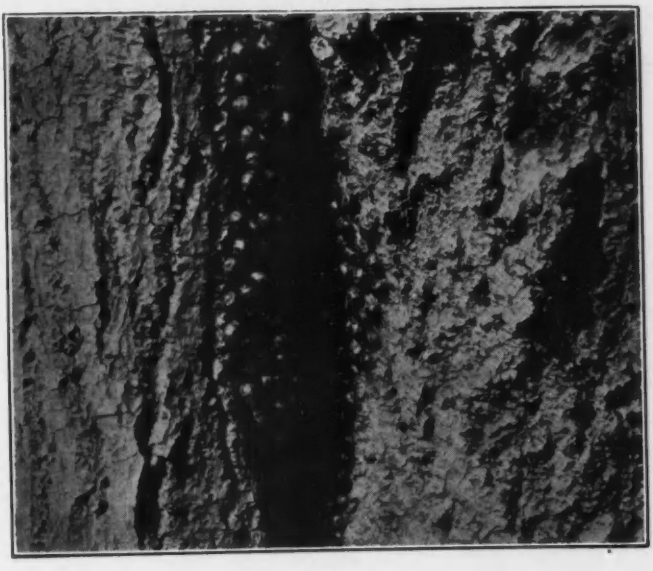
(3) **Gossard, H. A.** 1915. Report of committee on entomology for 1914. Ohio State Hort. Soc. 48th Ann. Meet., 107 pp., illus.
(4) **Howard, N. F.,** and **English, L. L.** 1924. Studies of the Mexican bean beetle in the Southeast. U. S. Dept. Agr. Bull. 1243, 51 pp., illus.
(5) **Underhill, G. W.** 1923. The squash lady-bird beetle. Va. Agr. Exp. Sta. Bull. 232, 24 pp., illus.

EXPLANATION OF PLATE

FIG. 1 (Upper). Stages of the squash beetle.
Adult; egg mass; fourth instar larva; two pupae.
(Photograph by Neals F. Howard.)

FIG. 2 (Lower.) Squash beetles hibernating on an oak tree.
(Photograph by D. E. Fink.)





TWO NEW MALLOPHAGA

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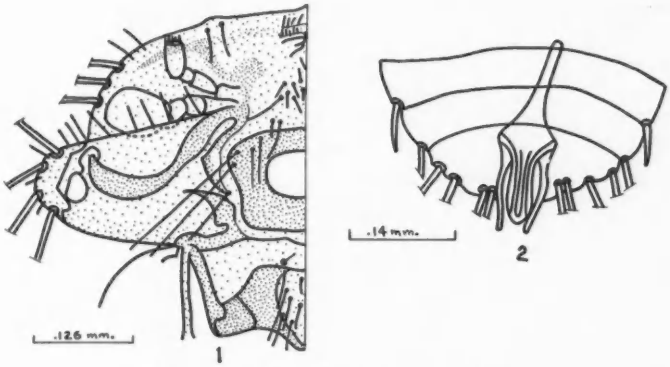
Machaerilaemus complexus n. sp.

Female: The head is more than twice as broad as long. Figure 1 shows the ventral aspect of the head and prosternal plate. The cephalic margin is slightly angular. The sides are swollen and form a flap over the antennal fossa. The unpigmented eyes are prominent and without spines. The most remarkable feature is the gular plate. It lacks distinct caudally projecting spineous processes which are characteristic in all other species in this genus. On each side of the caudal margin of the



FIGS. 1 and 2. *Machaerilaemus complexus.*
Fig. 1, Forehead of female. Fig. 2, Caudal segments and genitalia of male.

gular plate is a heavily chitinized triangular area. The gular plate contains a very conspicuous oval opening. The palpi are four-segmented; the distal segment the longest; the third segment is about half as long as the first and second.

Prothorax: The prothorax is winged and has an interscapular bar (interscapularis) between the scapulars dorsad to the sternal plate. The claviculars are strongly formed and pass ventro-endocaudad to fuse with the lateral angles of the prosternum. The coxae of the first pair of legs are elongate; the femora are extremely large; the tibia are long and taper at the proximal end. The first segment of the tarsus of all three pairs of legs bears a flap-like process.

Meso and Metathorax: The meso- and metathorax viewed from the dorsal side resemble the abdominal segments.

Abdomen: The abdomen is widest at the fourth and fifth segments; is dark straw colored with transverse bands showing brown. The last segment is nearly rectangular and fringed with two kinds of setae, about 12 long ones, as long as the segment and about 24 shorter ones, scarcely half the length of the former.

Male: The male is much lighter in color and smaller than the female. Caudal segments including genitalia are shown in Figure 2.

Chaetotaxy: The forehead of the female (Figure 1) has three very long setae and caudad to the mandibles are nine short setae. The temporal angle has four very long setae and three short ones. The antennal fringe has eight short setae. The gular plate has eight setae, two very long ones and two short ones on each side, located near the latero-cephalic margin. The poststernal plate has 14 setae, seven on each side. The mesosternal angle or plate has 12 setae, and the metasternal plate has 20 setae. Three or four short spines are present on each side of the abdominal sternal segments from 2–6 inclusive. The male has three short spines on the latero-ventral angle of the first abdominal segment and one or two similar spines from segments 2–7, inclusive.

TABLE I

MEASUREMENTS IN MM.

	MALE		FEMALE	
	L	*B*	*L*	*B*
Head	.196	.45	.21	.51
Prothorax	.14	.31	.14	.37
Mesothorax	.07	.35	.07	.45
Metathorax	.07	.35	.07	.49
Abdomen	.46	.40	.59	.59
Total	.936		1.08	

Type host, Spizella pusila pusila (Wils.), Field sparrow.

Type locality, Oak Lane Country Day School, Philadelphia, Pa.

Type slides, deposited in the Illinois State Natural History Survey, Urbana, Illinois. Holotype ♀, slide 13116; 3 paratype ♀, sls. 13117–13119, allotype ♂ and paratype ♂, sls. 13120.

Described from four females and two males taken Oct. 8, 1933, by R. O. Malcomson.

KEY TO SPECIES OF THE GENUS MACHAERILAEMUS
(Harrison)

Gular plate irregular in shape, circular opening in center. Four caudally projecting spinose processes, caudal pair each with one long seta; cephalic pair each with two long setae..... **uricolis** Bedford

Gular plate with circular opening in center; with two caudally projecting spinose processes; 6–7 setae on each side of the gular plate... **latifrons** Harrison

Gular plate without circular opening in center; with two caudally projecting spinose processes; two long setae on each side of the gular plate, **maestum** Kellogg and Chapman

Gular plate heart-shaped, with two caudally projecting spinose processes; 5–6 setae on each side of the gular plate..... **ploci** Bedford

Gular plate quadrangular in shape, circular opening in the center; two caudally projecting spinose processes. Prothoracic sternal plate concave on the cephalic margin..... **laticorpus** Carriker

Gular plate quadrangular in shape, with circular opening in the center. No distinct caudally projecting spinose processes present. Four setae on each side of the gular plate. Prothoracic sternal plate angular and hyaline in the median portion..... **complexus** n. sp.

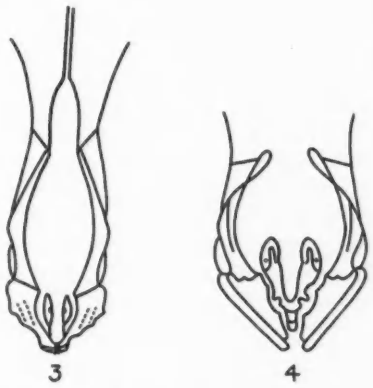


FIG. 3. *Columbicola extincta*, genitalia of male.
FIG. 4. *Columbicola columbae* Linn., genitalia of male.

Columbicola extincta n. sp.

Female: This species has all the characteristics of the genus *Columbicola* with exception that recurved setae are not present. The setal pit is present, but no setae were found on the fifteen specimens examined. The female of *extincta* n. sp. is smaller than the female of *C. columbae* Linn.

Male: The justification of placing this as a new species is the form of the genitalia, Figure 3, as compared to *C. columbae* Linn., Figure 4. The males of *C. extincta* n. sp. are longer than males of *C. columbae* Linn.

TABLE II

MEASUREMENTS IN MM.

	MALE		FEMALE	
	L	*B*	*L*	*B*
Head	.515	.28	.525	.287
Prothorax	.14	.21	.14	.189
Mesothorax	.077	.245	.08	.245
Metathorax	.175	.245	.08	.245
Abdomen	1.239	.44	1.40	.322
Total	2.146		2.225	

Dr. Ewing of the National Museum, Washington, D. C., suggested the name of *extinctus* which surely is a suitable one for the Passenger Pigeon is now extinct and probably has carried the parasite into extinction with it.

The Holotype male and Allotype female on the type slides were collected from the type host *Ectopistes migratorium* Linn., Passenger pigeon skin, which was taken by Prof. Frank Smith, Emeritus of the University of Illinois at the type locality, Urbana, Illinois, in 1895. Type slides deposited in the Illinois State Natural History Survey, Urbana, Illinois. The paratypes are in the U. S. National Museum collection and my own personal collection. Description was made from ten males and five females: holotype ♂, sl. 13121; allotype ♂, sl. 13122.

I am thankful to Dr. H. E. Ewing, of the U. S. National Museum, Washington, D. C., for checking this material.

BIBLIOGRAPHICAL INTRODUCTION TO THE STUDY OF CHINESE INSECTS (ENTOMOLOGICAL REPORT No. 1), by YOSHIO OUCHI, pages 1–78 of the full "Report No. 1," which is in the Journal of the Shanghai Science Institute, Section III, Vol. 2, pp. 1–533. 1934.

Except for the names of authors and of foreign publications the entire volume is of Chinese characters. Pages seven to 78 are in tabular form following which are nine larger folded tables and a plate of graphs.

The work is apparently a digest in tabular form of the sources of information on Chinese insects. We have not seen the full work of which this is an introductory part.—C. H. K.

NUMBER OF INSTARS OF THE PINK BOLLWORM COLLECTED IN SQUARES AND IN BOLLS OF COTTON

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During the summer of 1932 attempts were made to determine the number of instars of the pink bollworm, *Pectinophora gossypiella* (Saunders), and their duration by periodic examination of artificially infested squares for exuviae. As the exuviae, especially those of the early instars, were exceedingly difficult to find, this method failed to give the desired results. The method of Peterson and Haeussler (4) was then employed successfully. This method, which was recently discussed by Gaines and Campbell (2), involves the grouping of measurements of samples of the population collected at intervals during the development of a brood or at a time when individuals representing all instars are present.

PROCEDURE

In October, 1932, about 600 pink bollworms were collected at random from squares and blooms of various ages and placed in vials containing 70 percent alcohol. Later about 230 more larvae were collected from bolls and preserved in the same way. In all of these larvae the dorsal aspect of the head capsule at its greatest width was measured with the aid of a binocular microscope and an ocular micrometer. Each small unit in the 10× ocular was calibrated to measure 0.0225 mm. for the first and second instars and 0.06 mm. for the third and fourth instars. Measurements were made to the nearest one-half unit on the micrometer.

RESULTS

As larger samples were studied from squares than from bolls, the results on samples from squares will be discussed first and in greater detail. The measurements of the width of head of pink bollworms collected from squares, together with their frequencies, are given in Table 1. This table, which shows the distribution of the measurements, is sufficient to prove that there were four instars in the material studied, because four essentially unimodal groups were found, the extreme measurements of which did not overlap.

It will be noted that the frequencies do not increase regularly to a maximum and decrease regularly, but high and low values tend to

[1]The writer acknowledges the assistance of F. L. Campbell, Bureau of Entomology and Plant Quarantine, in revising the manuscript.

alternate. This is due to the difficulty of estimating measurements to one-half units on the micrometer eyepiece, with a resulting tendency to read in whole units. If frequency distributions were plotted as given in Table 1, the distributions would show a fictitious irregularity. Therefore, in Figure 1 a two-point moving average was used to smooth the curves, and other adjustments were made to bring out relationships not evident in Table 1. Because the number of insects measured was not the same in all instars, percentage frequency was used instead of actual frequency, and because the class intervals for the first and second instars were not the same as those for the third and fourth, the former measurements were grouped into the class intervals of the latter, both adjustments being made to facilitate comparison of the four distributions. As

TABLE I

DISTRIBUTION BY INSTARS OF MEASUREMENTS OF THE HEAD WIDTH OF PINK BOLLWORMS COLLECTED IN COTTON SQUARES

First Instar		Second Instar		Third Instar		Fourth Instar	
Head Width	Frequency	Head Width	Frequency	Head Width	Frequency	Head Width	Frequency
Mm.		*Mm.*		*Mm.*		*Mm.*	
0.146	1	0.225	1	0.480	3	0.870	2
.157	114	.236	0	.510	9	.900	5
.168	9	.247	9	.540	43	.930	7
		.258	11	.570	25	.960	28
		.269	25	.600	67	.990	13
		.280	17	.630	17	1.020	48
		.291	35	.660	17	1.050	24
		.302	21	.690	1	1.080	50
		.313	22	.720	1	1.110	8
		.324	4	.750	0	1.140	12
		.335	8	.780	3	1.170	4
		.346	2			1.200	2
		.357	1			1.230	1
						1.260	2
						1.290	1
						1.320	2
						1.350	1

all the measurements of the first instar fell into one class interval, a straight line had to be drawn to represent this distribution.

Figure 1 shows four unimodal distributions, each representing an instar. The range, or the absolute variation, in measurements increases from the first to the fourth instar as the distributions become flatter, but the variation relative to the means of the last three instars is almost constant, as shown by the coefficients of variation in Table 2.

Gaines and Campbell (2) have concluded that Dyar's rule (1) is not dependable for corroborating the number of instars observed, and that it should not be used for this purpose. However, it is always of interest to know how closely a given series of observed mean head widths follows a geometrical progression. The present series agrees well with the values computed from the logarithmic curve log $y=a+bx$, the growth ratio

being 1.89, determined by the method of least squares. The observed and calculated means, and their differences expressed as percentages, are given in Table 2 and plotted in Figure 2.

The measurements of head width of larvae collected from bolls are summarized in Table 3. There is greater variation in this material than in that collected from squares, but the presence of four instars is clearly indicated. The growth ratio of the larvae from bolls (2.04) was greater than that of larvae from squares (1.89), as shown by the greater

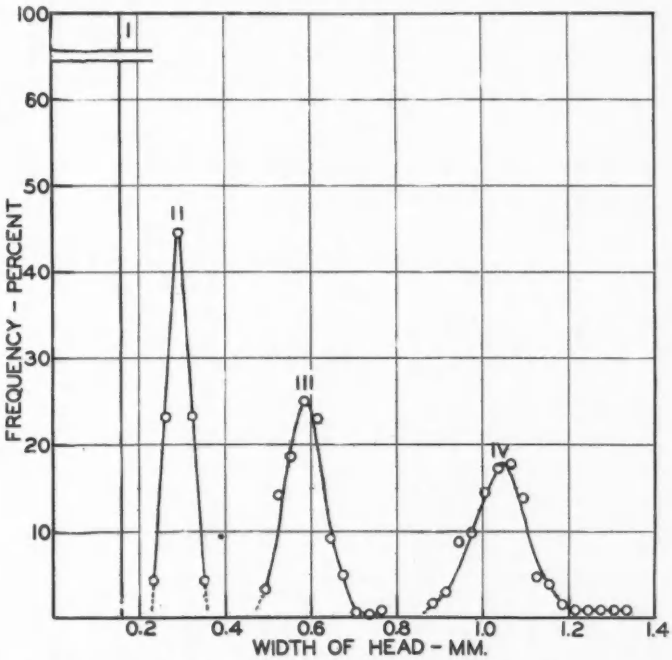

FIG. 1.—Frequency distribution of the width of head of pink bollworms collected from cotton squares, to show the occurrence of four instars.

slope of the dotted line in Figure 2. It may be significant that the points of both lines in Figure 2 deviate similarly from the lines. For example, the points for the second instar are both below their respective lines, those for the third instar are above their lines, and those for the fourth are below. This uniformity of deviation may indicate a real departure from a geometrical progression.

Measurements of length of larvae are included in Tables 2 and 3 chiefly to show the overlapping of these measurements between instars as contrasted with the gaps between measurements of width of head. Obviously length of larvae, which changes during a stadium, would not be so suitable for characterizing instars as width of head, or a dimension

TABLE II

A Summary of Measurements of Head Width and Length of Larva of the Instars of the Pink Bollworm Collected in Cotton Squares

Instar	Width of Head						Length		
	Larvae Measured	Range	Observed Mean	Calculated Mean	Difference	Coefficient of Variation	Larvae Measured *	Range	Mean
	Number	*Mm.*	*Mm.*	*Mm.*	*Percent*	*Percent*	*Number*	*Mm.*	*Mm.*
First	124	0.146—0.168	0.158±0.0002	0.158	0.0	1.93	(a) 86	0.855—1.282	1.073
							(b) 38	1.440—2.407	1.803
Second	156	.225— .360	.291± .0013	.298	—2.3	8.47	155	1.687—4.095	2.790
Third	186	.480— .780	.588± .0025	.564	+4.3	8.53	183	2.770—10.080	5.831
Fourth	210	.870—1.350	1.044± .0036	1.065	—2.0	7.46	210	5.580—13.920	10.588

*(a) refers to newly hatched larvae and (b) to larvae cut out of squares.

TABLE III

A Summary of Measurements of Head Width and Length of Larva of the Instars of the Pink Bollworm Collected in Cotton Bolls

Instar*	Larvae Measured	Width of Head					Length	
		Range	Observed Mean	Calculated Mean	Difference	Coefficient of Variation	Range	Mean
	Number	*Mm.*	*Mm.*	*Mm.*	*Percent*	*Percent*	*Mm.*	*Mm.*
Second	57	0.247—0.382	0.308±0.0029	0.322	—4.3	10.61	1.305— 3.937	2.411
Third	66	.405— .990	.712± .0118	.657	+7.7	19.96	1.890—10.020	6.759
Fourth	100	1.080—1.500	1.290± ——†	1.342	—3.9	——†	6.840—16.740	12.103

*The measurements of the first instar from bolls were practically the same as those from squares (Table II).
†Original data mislaid.

of some other sclerotized part of the body, which does not change during a stadium.

As a matter of interest, 84 pupae ranged in width from 2.16 to 2.94 mm. (mean 2.596 mm.) and in length from 6.18 to 8.94 mm. (mean 7.568 mm.).

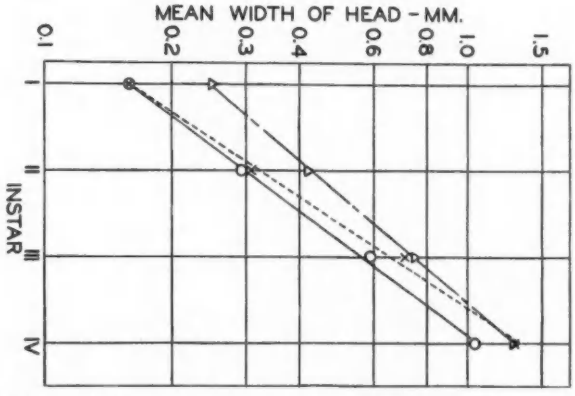

FIG. 2.—Relation between observed mean head widths of each instar of the pink bollworm (represented by points) and geometrical progressions (represented by lines) best fitting these points. Data represented by the solid line and circles are for *Pectinophora gossypiella* collected from cotton squares; the dotted line and crosses for *P. gossypiella* from bolls; and the dot-and-dash line and triangles for *P. scutigera* (Holdaway's data).

DISCUSSION

In his study of the pink bollworm of Queensland, (*Platyedra*) *Pectinophora scutigera* Hold., which is closely related to *P. gossypiella*, Holdaway (3) apparently determined the number of instars of this species in the same way as did the present writer, for he says, "No breeding experiments to determine the number of stadia passed through during the larval life of the insect have been carried out, but from the measurements of the head-capsules of a large number of larvae, it would appear that there are four instars." The relation of Holdaway's measurements to those of the writer is shown in Figure 2, the dot-and-dash line representing the geometrical progression best fitting his observations.

In comparing mature larvae of *P. scutigera* and *P. gossypiella*, Holdaway stated that the average width of head of the former species was 1.28 mm. and of the latter, 1.17 mm. These averages were obtained by measuring 15 larvae of each species. However, no mention is made of the host plant or of the type of fruiting form on which these larvae developed. Figure 2 shows

that the head of the *scutigera* may be wider than that of *gossypiella* in the last instar, but the largest and most significant difference is in the mean head widths of the first instar, which is 0.25 mm. for *scutigera* and 0.158 for *gossypiella*. The growth ratios of the two species are also quite different, being 1.73 for *scutigera* and 1.89 or greater for *gossypiella*. The growth ratio of 2.04 for *gossypiella* from bolls is unusually high for a lepidopterous larva.

SUMMARY

About 600 pink bollworms, *Pectinophora gossypiella* (Saunders), were collected from squares of cotton and about 230 from bolls and preserved in alcohol. Later the head width and length of each larva were measured. The measurements of the head width, when arranged in numerical order together with the frequency of each measurement, fall into four distinct unimodal groups each representing an instar. When smoothed and plotted in a manner permitting comparison, the frequency distributions of head widths of larvae from squares showed the presence of four instars.

When the observed mean head widths for the two series were compared with values obtained from geometrical progressions computed from the data, the agreement was close, indicating that the head widths of the instars fall in a geometrical progression as stated by Dyar. The common ratio or growth ratio of the progression for the specimens from squares was 1.89 and from bolls, 2.04, but the mean head width of both groups of larvae was the same in the first instar.

The head measurements on *P. gossypiella* were compared graphically with similar measurements published by Holdaway on a closely related species from Queensland, *P. scutigera*, which was also shown to have four instars. *P. scutigera* had a growth ratio of 1.73, and the mean width of head of the first instar was markedly greater than that of *P. gossypiella*.

The length and width of 84 pupae of *P. gossypiella* were also measured.

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HONEYBEE MONSTROSITIES

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In 1934 the writer described[1] in detail a gynandromorphic honeybee in which one-half of the body was male and the other half female, with parts of both sex organs present. Reports of such monstrosities in the honeybee are uncommon in beekeeping literature. Many apiarists and investigators have never seen them after working with bees for years. It is possible, however, that the phenomenon is more common than the scattered reports would indicate due, probably, to the fact that such individuals are abnormal in function as well as in structure and are driven out of the hive by the other bees to be destroyed by other insects and the elements.

In June, 1935, a queen was received from Roy Hawthorne of Taber, Alberta, for examination to determine the probable cause of her failure. The queen had been received by him in a package of bees and was removed because of the small amount of brood she had been able to produce. She was introduced successfully into a three-frame nucleus in the apiary of the University of California, at Davis, and soon had brood in all three frames with only a few drone cells. Shortly after her bees began to emerge, a small drone-like bee was seen momentarily as it crawled over a top bar. A careful search the next day not only disclosed this bee but one other monstrosity as well. Subsequently, seven additional abnormal bees were found in the same nucleus. Each individual specimen had been reared in a worker cell and consequently was approximately equal in size to a worker bee. A description of the monstrosities is interesting primarily because of the varied physical characteristics produced in different specimens coming from the same queen as well as the rareness of such occurrences.

DESCRIPTION OF THE GYNANDROMORPHS

Specimen No. 1.—This bee was 13 mm. in length and resembled a small drone in appearance. The left side of its head bore a compound eye similar to that of a drone while the right eye was that of a worker.

[1]Eckert, J. E., 1934. Jour. Ec. Ent. 27 (5): 1079–1082.

The left antenna was 13-jointed, the right, 12-jointed. The left maxilla was shorter than the right and the left mandible was broader and notched like that of a drone. The glossa curved to the left, being shorter on the left side than on the right side. There was a visible ridge running vertically through the middle of the head. Two small ocelli were to the left of the median line below the vertex while a large ocellus was situated on the vertex to the right of the median line.

The dorsal part of the abdomen resembled that of a drone but a vestigal sting and sting palpi were visible externally. Upon dissection, well developed male reproductive organs were present. No spermatheca or ovaries could be found. Both hind legs bore pollen baskets.

Specimen No. 2.—This creature had the compound eyes of a drone, 12-segmented antennae, one large ocellus below the vertex to the right of the center of the front and two smaller ocelli below on the left side near the base of the left antenna. The left maxilla and labial palp were shorter than those on the right side and the glossa was curved to the left as in Specimen No. 1. The left postcerebral gland and the left thoracic salivary gland were better developed than like glands on the right side. The midgut and hindgut were full of pollen, indicating that the specimen had taken food.

Six segments were visible dorsally on the abdomen, the first four resembling those of the drone. A sting was well developed and large accessory glands of the male were present.

The body of the bee was black and covered with long yellowish pubescence. The legs were typically female in structure.

Specimen No. 3.—Both the compound and simple eyes resembled those of a drone, and were located normally. The mouth parts, including the mandibles and proboscis were regular and similar to those of a worker. The antennae were 12-jointed. The sting was normally developed and no male organs were present. The hindgut was congested with pollen and fecal material. The legs were those of the worker bee. The bee was similar in color to Specimen No. 2 and was several days old when discovered.

Specimen No. 4.—This bee was 16 mm. long, had the eyes of a drone and female antennae. The mouth parts resembled those of Specimen No. 1. The legs were of the female sex. There was a distinct ridge down the middle dorsal portion of the thorax, the left half of the thorax being black and the right half yellow in color. Seven segments of the abdomen were visible dorsally. The second dorsal abdominal segment was irregularly notched along the posterior border instead of being smooth, while the third segment was mottled with yellow and black colors. The sting was well developed and no male organs were present. The legs and wings were like those of the worker.

Specimen No. 5.—This bee resembled a good Italian worker with the exception that the right compound eye was that of a drone and the left eye was that of a worker. The mouth parts, legs, wings, and abdomen were normally female in structure. A slight ridge extended dorsally for three-fourths the length of the thorax. From all appearances, the specimen was several days old when discovered.

Specimen No. 6.—This individual very closely resembled Specimen No. 4, even to the irregular border on the second dorsal abdominal segment. It was only 14 mm. long, however, and was very hairy on the ventral surface.

Specimen No. 7.—This specimen was picked up on the outside of the nucleus with the antennae and mouth parts missing. Both compound eyes were drone. A ridge extended from the fore part of the thorax through the dorsal part of the abdomen, and an extra half of a segment was attached to the second abdominal segment on the left side. The sting was normally developed and the legs were those of a worker. As the specimen was considerably dried, no dissection was attempted.

Specimen No. 8.—This bee closely resembled Specimen No. 5 even to the slight ridge that extended partially through the mesothoracic segment. The first tarsal joint of the middle right leg was grooved like the tibia of the hind leg forming the pollen basket; otherwise, the legs were normally female. This specimen was several days old when discovered.

Specimen No. 9.—This individual very closely resembled Specimen No. 5.

BEES BORN WITHOUT ANTENNAE OR MANDIBLES

In investigating some probable causes of supersedure of queens shipped in package bees, the writer exposed a number of queens to cold temperatures for varying periods of time. One of the queens which had been normal in all respects before being exposed to a temperature of 34° F. for a period of 5 hours began laying regularly after exposure but a large number of the resulting bees were born with abnormally shaped heads. Fully 10 per cent of the total adults produced over a period of several weeks were such individuals. Their bodies appeared normal in every particular but the heads lacked an antenna, or a mandible, or an antenna and one mandible, or both antennae, or a combination of antennae and mandibles were lacking.

Close examination revealed that these organs had not been torn or broken off. Bees without mandibles were unable, in many cases, to emerge and died either in or part way out of their cells. Some of their heads were extremely small and misshapen and in a few cases the mandibles were quite vestigial and entirely different in structure from the normal mandible. Some of the antennae were malformed, at times being nothing more than stubs.

In those individuals that lacked one or both antennae, no antennal sockets were present and that part of the head instead of being concave was pushed out, rounded, or convex in shape. In every specimen examined, the proboscis of each one was normal in structure even when the head was only about one-fourth normal size.

It was particularly interesting to note that large numbers of the individuals that lacked only one antenna or a mandible were tolerated by the other normal individuals of the nucleus. The bees with only one antenna were able to orient themselves in a normal manner, flew in a straight line when released some distance from a laboratory window and engaged in certain activities in the hive and afield. On several occasions,

individual bees with only one antenna acted in the capacity of fanners or as guards at the entrance and in one instance a bee with but one antenna was observed to return to the nucleus with a load of pollen. These examples serve as positive evidence that such creatures had been able to make adjustments for the missing organ. It was noticed, however, that when such bees went through the motions of cleaning their antennae, as is frequently done before each flight, they used both forelegs and rubbed repeatedly on the side where the antenna was missing. This observation was repeated several times in order to make sure of the motions involved. It was evident that the association centers in the brain were functioning normally even though an end organ was missing. In the case of one guard at the entrance, the bee with one antenna missing was slower to challenge the passing bees and at times missed them completely, apparently due to its slower reaction time.

An examination of 100 bees born with some part or parts of the head missing can be summarized in the following manner:

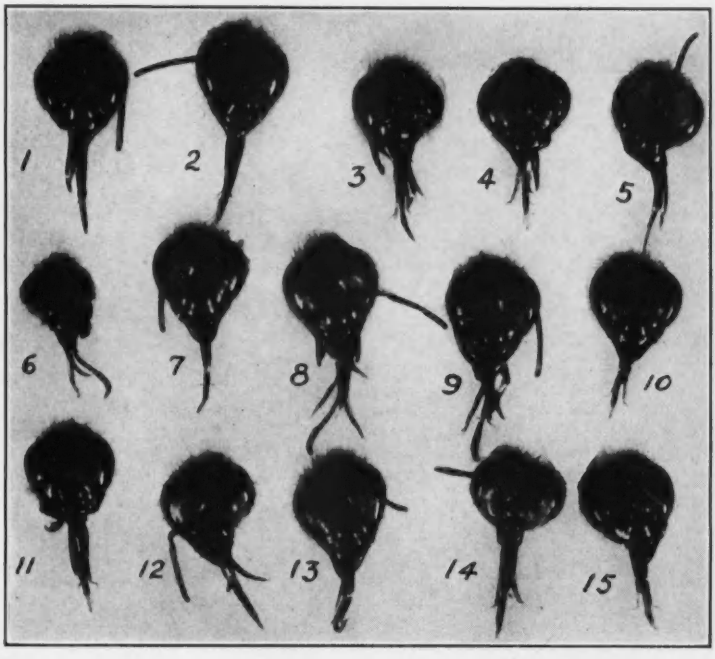
Part Missing	*Number of Bees so Affected*
Left antenna only	14
Right antenna only	6
Both antennae only	6
Left mandible only	1
Right mandible only	1
Both mandibles only	4
Left antenna and left mandible	10
Left antenna and both mandibles	6
Right antenna and right mandible	10
Right antenna and both mandibles	4
Both antennae and both mandibles	23
Both antennae and left mandible	2
Both antennae and right mandible	4
Antenna malformed only	8
Mandible malformed only	1
Total	100

In most specimens in which one mandible was missing, the proboscis quite often was twisted sidewise into the open space, demonstrating that the presence of the mandibles tend to keep the proboscis of the bee in correct position. Most of the creatures that had both mandibles and antennae missing had extremely small heads with the compound eyes reduced asymmetrically. The hairy covering on these small heads was unusually dense and long, giving the bee a resemblance to some of the larger mutillids.

The fact that such insects with only one antenna could orient themselves in a fairly normal manner, fly straight when released in the apiary or below a window, and engage in certain other normal activities, raises several interesting questions, particularly in regard to the influence the antennae have as balancing, orienting, or olfactory organs. If such creatures could be obtained in sufficient numbers, it would be interesting to test out their reaction time to odors in contrast to normal bees and to repeat certain experiments that have been made with mutilated bees or bees whose antennae had been covered with shellac.

It is also interesting to surmise as to the manner in which these abnormal individuals were produced. The queen was only one of several queens exposed to severe cold that produced these results. Why were the differences confined only to the head? And did the cold affect the generative cells in the ovaries of the queen or did it change some of the genes in the spermatazoa confined in her spermatheca? It would seem that the latter premise is the more plausible for only a portion of the bees were so affected. No drones were produced by this queen that could be used as checks against the workers.

Unfortunately, this nucleus was one of many colonies on the University Farm that were destroyed by the use of the airplane in broadcasting poisons in the vicinity in an attempt to control insect pests in tomato fields.



Heads of honeybees that emerged without a full complement of antennae or mandibles, University Farm, Davis, California.

PARTS MISSING

1. Right antenna and right mandible.
2. Left antenna.
3. Left antenna and mandible, right antenna malformed.
4. Both antennae.
5. Right flagellum and left mandible.
6. Both antennae and both mandibles.
7. Left antenna.
8. Right antenna.
9. Right mandible.
10. Both antennae.
11. Both antennae and mandibles. Peculiarly shaped structure in place of right mandible.
12. Left antenna, mandible and gena.
13. Right antenna.
14. Left antenna and both mandibles.
15. Both antennae and right mandible.

THE SEASONAL CYCLE OF PHYLLOXERA NOTABILIS PERGANDE (PHYLLOXERIDAE, HOMOPTERA)

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Phylloxera notabilis was described in 1903 by Pergande (1). He recorded it as being collected at St. Louis and Bluffton, Missouri; and Idle Wild and Austin, Texas. Baker (2) stated that this insect was very numerous in Louisiana and Whitehead (3) recorded it as abundant in the vicinity of Stillwater, Oklahoma. Although this species has been recorded from but four states it is the writers' opinion that a survey would show it to be present throughout most if not all of the pecan belt.

Hosts.—So far as is known the pecan (*Hicoria pecan*) is the only host. Pergande (1) mentioned but one variety of pecan (Meier) from which his specimens were taken, but so little had been accomplished toward the propagation of pecans at the time these observations were made it seems probable that the other specimens collected were from native or seedling pecans. Baker (2) states "Infestations of *P. notabilis* which have been observed in Louisiana have been confined to the Pabst variety and to some seedling trees." In the vicinity of Stillwater they have been most frequently observed on seedling trees but have also been collected in small numbers from most of the propagated varieties found in the college pecan orchard.

Since this species occurs only on pecan leaves so far as known, and since it appears to be by far the most common phylloxera on pecan leaves, the "Pecan Leaf Phylloxera" is hereby proposed as the common name for *Phylloxera notabilis* Pergande.

Economic Importance.—The pecan leaf phylloxera appears to be of comparatively small importance economically. Whitehead (3) concluded that they are not of sufficient importance in Oklahoma to warrant the use of control measures and Baker (2) states, "Trees attacked are seldom seriously damaged though in instances of severe infestation, there may be considerable premature defoliation. Trees quite heavily infested have been observed to mature their crop in fair condition and to set a crop the following year." In no case have they been reported to cause severe injury on a large scale.

Technique.—No method was found of rearing the insects in the laboratory and therefore the studies consisted mostly of field observations. Sticky bands were placed around the twigs to prevent the escape of apterous forms and bolting-cloth bags were used to enclose the infested leaves when winged forms were present. Infested leaves were brought into the laboratory and observed under a binocular microscope for detailed studies.

Overwintering Stage.—*Phylloxera notabilis* passes the winter in the egg stage well concealed usually in crevices of the bark although they may be found any place where protection is afforded. Such eggs are lemon-yellow in color when first deposited but soon turn to a light reddish brown. They are about 0.3 mm. in length and 0.18 mm. in diameter. The overwintered eggs begin hatching about the last of April and continue hatching for three to four weeks. The peak of hatching occurs early in May.

The Stem Mother.—The form which hatches from the overwintered egg, the stem mother, crawls to the new growth, selects a leaf which has not as yet unfolded, inserts her beak and begins feeding. In one to two days the cells of the leaf surrounding the feeding puncture begin an abnormal growth. They grow up around and over the stem mother in such a manner that she first appears to be in a depression and later is completely enclosed in the gall thus formed. The usual length of time from beginning of feeding to closing of the gall is six days. She moults three times, the first occurring about the time the gall closes and the others at two- to three-day intervals. Shortly after the last moult the stem mother begins to oviposit pearly white eggs within the gall. The eggs hatch in approximately two days, and the young nymphs, together with the stem mother, feed from the inner wall of the gall.

The Galls.—The growths produced by the stem mother are always formed on the ventral surface of the leaves. They are more or less globular in shape but usually the diameter parallel to the surface of the leaf is somewhat greater than that perpendicular to it. In color they are greenish frequently tinged with red. They are situated on either side of the mid rib and between the larger veins. Their greatest diameter ranges up to 18 or 20 mm., although the average size is much smaller. The first generation of galls will average two to four times larger than those of later generations. The number of phylloxerae within a gall normally varies directly with the size of the gall. In some of the largest galls more than a thousand individuals were produced. In from four to five weeks from the time the galls are started they reach maturity and crack open, thus freeing the phylloxerae which have developed in them.

Although during the first three instars all the offspring of the stem mother found in the galls are very similar in appearance, biologically they represent two distinct types of females. One type reaches sexual maturity and oviposits after three moults, whereas the other matures after four moults. The first type of females are the sexuparae, the second type the migratory females.

The Sexuparae.—Although wing pads are present in the sexuparae, functional wings are not developed. Each instar is passed in three to four days. After the third moult the sexuparae may be distinguished from the migratory females by the fact that they are dusky yellow in color while the others are orange or lemon yellow and also because they have somewhat longer antennae. A considerable portion of the sexuparae reach maturity before the gall matures and these begin depositing eggs within the gall. After the galls have matured and cracked open the sexuparae emerge from the gall and continue egg deposition on parts

of the tree near the gall. They produce two sizes of eggs which are bright yellow in color, highly polished, and have a granulated appearance. The incubation period of the eggs produced by the sexuparae is approximately eight days after which the sexuals emerge.

The Sexuals.—The females emerge from the larger eggs, the males from the smaller. The mouth parts are vestigial and these individuals never feed. The females are about .25 mm. in length, the males approximately a third smaller. They are sexually mature when they hatch and mating occurs soon after, either within the gall or after they have emerged. After mating the females find a place of concealment, usually in the cracks of the bark, where a single egg, almost as large as the individual that deposits it is extruded from the body. These are the overwintering eggs and do not hatch until the following spring.

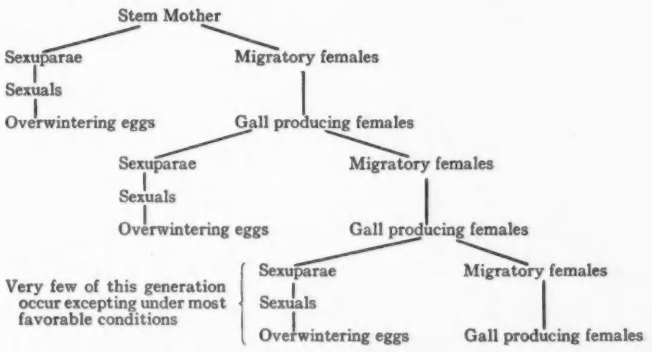

FIG. 1. Seasonal cycle of *Phylloxera notabilis* Perg. in the vicinity of Stillwater, Oklahoma.

Migratory Females.—As stated before, the migratory females pass through one more instar than the sexuparae and develop functional wings. They are from 0.6 mm. to 0.8 mm. in length with a wing expanse of approximately 2.4 mm. and are easily distinguished from all other forms by the fact that they are the only ones having fully developed wings. They, like the sexuparae, usually reach maturity before the gall opens and deposit some of their eggs within the gall. As soon as the gall opens, however, they emerge and fly at once to another part of the same tree or to other trees and deposit eggs that are very similar in appearance to those of the sexuparae. Such eggs have an incubation period of six to seven days. (See Figure 1.)

Gall Producing Females.—The individuals that hatch from the eggs of the migratory females are known as gall producing females and are very similar in appearance and habits to the stem mother. They crawl to newly developing leaves and there produce a second generation of galls. These galls are similar to those caused by the stem mother, but due to the fact that the new leaves develop much more slowly at this

time of year than in early spring the galls also are slower in developing. As a result the average size of the mature galls is much smaller, and likewise the number of individuals produced within them is much smaller. The same types of individuals develop in these galls that developed in those of the first generation.

The length of time from the finding of the first stem mothers until the second generation of galls is started is approximately 40 days. The length of time required for this cycle would indicate the possibility of three generations of galls each year.

The study of the later generations, however, was complicated by several factors: First, individuals that were handled seldom produced galls; second, hot dry weather slowed up the development of the new leaves so that the mortality rate was high and most of the individuals under observation died; third, predaceous and parasitic enemies still further increased such mortalities; and lastly, the latest of earlier generations overlapped with the earliest of succeeding generations. As a result of the above factors it was not definitely determined whether there was a third generation of galls. At any rate the later generations were so greatly reduced that they played but a small part in either the life economy of the insect or its economic importance.

The hot dry spells that are so typical of Oklahoma summers probably account for the fact that this species of phylloxera is of less importance here than in the more humid parts of the pecan belt where weather conditions do not so definitely slow up the new growth. Its seasonal cycle in the vicinity of Stillwater is illustrated in Figure 1.

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TWO-SEGMENTED TARSI IN COCCIDS: OTHER NOTES (HOMOPTERA)[1]

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If one examines as they occur on the book shelf three or four keys to the Homoptera he is apt to find in one or more of them that one of the main key characters used is the number of segments in the tarsi. Thus:

A. Tarsi 3-jointed.....*Auchenorhyncha* (*Cicadidae, Cercopidae, Jassidae, Membracidae,* and *Fulgoridae*)
B. Tarsi 1- or 2-jointed.....*Sternorhyncha*

The number of tarsal segments is again frequently employed in separating the two groups of the Sternorhyncha, as:

1. Tarsi 2-jointed, etc.....*Aleyrodidae, Aphididae, Chermidae*
2. Tarsi 1-jointed, with a single claw. Females apterous, and often devoid of legs, scale-like, or covered with waxy material. Males dipterous, mouth-parts atrophied.....*Coccidae*

In most keys of this type some characters of both male and female coccids are given, although within the group itself the custom has been to use chiefly the characters of the female. Because so little, relatively speaking, has been published about male coccids and because female coccids are more specialized than the males it seems desirable to study the males.

When living specimens of males are secured the opportunity should not be neglected to make mounts immediately. Even recently dead, but undried, specimens can be used. I like, however, to place them alive and kicking directly in euparal on the slide and then put the cover glass in place. This can be done quickly, and often when it would not be possible to make stained mounts for lack of time. Such a practice, made a habit of over a period of years, will result in a surprising amount of material for the little effort required compared to the time needed to properly prepare and stain for mounting such specimens after they have become thoroughly dry. These fresh euparal mounts will keep for years in excellent condition and if later on no unmounted specimens are available and stained

[1]A contribution from the Mississippi State Plant Board.

specimens are desired they can be removed from the slide, treated and stained according to one's favorite method, and remounted. The danger of breaking or mutilating specimens in process of preparation for mounting in the usual way is considerable lessened and no specimens need be lost when the material is fresh, and they are mounted directly in euparal. These advantages often offset the lack of stained specimens, especially for small, lightly chitinized males such as those of the diaspidines. Such fresh material is in better condition for study a day or so after mounting than it is immediately after the cover glass is put in place.

In many species the legs are wanting or are rudimentary in the females. This fact is pointed out in most text books on entomology when it has generally been accepted that coccids have 1-segmented tarsi, though sometimes allowance has been made for exceptions to this general rule. However, the method of mounting mentioned has fostered the accumulation of evidence that in the case of the male coccids the exceptions may prove to be the rule and our keys will perhaps need some rewording.

The tarsi of generalized coccids would be expected to be more like the tarsi of aphids than would the tarsi of the specialized diaspidines. Dr. Harold Morrison has stated that the males of most of the species of Margarodidae have two-segmented tarsi and that the females of the subfamily Xylococcinae have two-segmented tarsi unless the legs are rudimentary. (Morrison, Classification of Coccid Family Margarodidae, p. 33; p. 38, Fig. 1D; p. 156, Fig. 78F, 1928). Examination of specimens in these and in some other generalized coccids shows that the tarsi are similar to the tarsi of aphids, the first segment being short, more or less triangular in lateral aspect, and frequently sclerotized. Sometimes there is an articulation between the two tarsal segments as well as between the tibia and the tarsus. This condition, in which there is a distinct coila and artis between the two tarsal segments, is noticeable in *Labioproctus polei* Green, *Dactylopius confusus* (Ckll.), *Amonostherium lichtensioides* (Ckll.), *Ceroputo yuccae* (Coq.), *C. yuccae ceanothi* Ckll., *C. yuccae mexicanus* (Ckll.), *Phenacoccus gossypii* T. and Ckll., and *Pseudococcus citri* (Risso).

In the Ortheziidae, usually conceded to be the most generalized of all the coccid families, the tarsi of the males as well as of the females which I have examined are, with the exception

of one leg of one specimen, one-segmented, just as most keys indicate. This is true also of the small number of males which I have examined of the Asterolecaniidae and of the Lecaniidae. In the Kermesidae and in the most specialized of all the coccids, the Diaspididae, males have been examined in which the tarsi are one-segmented although of those seen a much larger percentage had two segments than had one segment in the tarsi.

The Diaspididae show an interesting variation in the structure of those tarsi which are two-segmented from that described in the generalized group two paragraphs above. Instead of appearing triangular in outline from the lateral aspect the first segment is short and button-like or disc-like in outline. No coila or artis has been observed. The division of the tarsus into two segments, however, seems to be as distinct in many specimens as the division between many other generally recognized segments of the legs of various species, as for example the division between the tibia and tarsus in the Ortheziidae. In other specimens this division occurs in varying degrees just as is found in the other joints of the legs, of different species and of different specimens in the same species, or even on the same individual. This type of tarsus is shown in the illustration accompanying my description of *Crypthemichionaspis ulmi* (Annals Ent. Soc. Amer., Vol. XX, No. 3, page 357, Figure 6, 1927) and is the type common to most of the diaspidines which I have examined. The other type has one-segmented tarsi. In several cases specimens have been examined which have one pair of legs with one segment in the tarsus and the other with two segments, or the other way around, or even with one tarsus distinctly two-segmented and with all the others one-segmented. These cases are not common and are apparently analogous to the variation in the number of segments in the antennae of some individual mealybugs, where one antenna will have eight segments and the other nine or seven as the case may be; or other variations on the two sides of some specimens.

From my notes on coccids I have compiled the following list of males which have two-segmented tarsi.

MALE COCCIDS HAVING TWO-SEGMENTED TARSI

In the list (below), an asterisk preceding a name indicates that this species is the type of the genus; the figures indicate the year the description was published.

DIASPIDIDAE

Diaspidinae

**Diaspis* (1828) *calyptroides=echinocacti* (Bouche) 1833, tarsi of middle legs distinctly 2-segmented, those of hind legs indistinctly segmented.
Diaspis echinocacti cacti (Comst.). 1883.
Diaspis texensis (Ckll.). 1896.
Fiorinia syncarpiae Mask. 1892.
Fiorinia theae Green. 1900.
**Howardia biclavis* (Comst.). 1883.
Kuwanapis bambusae (Kuw.). 1902.
Lepidosaphes dentata (Hoke). 1921.
Leucaspis stricta (Mask.). 1883.
Parlatoria blanchardi (Targ.). 1869.
Parlatoria pergandii Comst. 1881. Chaff Scale.
**Phenacaspis nyssa* (Comst.). 1881.
Pinnaspis aspidistrae (Sign.). 1869. Fern Scale.
Pinnaspis mussaendae (Green). 1896.
Pinnaspis quercus (Comst.). 1881.
Pseudaulacaspis pentagona (Targ.). 1885. White Peach Scale.
Unaspis euonymi (Comst.). 1881.

Aspidiotinae

Aonidia rhusae Brain. Anterior tarsi at least.
Aonidiella aurantii (Mask.). 1878. California Red Scale.
Aspidiotus abietis (Schr.). 1776.
Aspidiotus densiflora Bremner. 1907.
Aspidiotus destructor Sign. 1893.
**Aspidiotus* (1833) *hederae* (Vall.). 1829.
Aspidiotus pini Comst. 1881. Not as distinct as some, first legs more distinct than third.
Aspidiotus (*Diaspidiotus*) *ancylus* (Putn.). 1877.
Aspidiotus (*Diaspidiotus*) *perniciosus* Comst. 1881. San Jose Scale.
Aspidiotus (*Hemiberlesia*) *camelliae* Sign. 1869.
Aspidiotus (*Hemiberlesia*) *epigaeae* Marlatt. 1908.
Aspidiotus (*Hemiberlesia*) *lataniae* Sign. 1869.
Aspidiotus unilobis Mask. 1894.
**Chrysomphalus* (1880) *aonidum* (Linn.) 1758. Florida Red Scale.
Chrysomphalus rossi (Mask.). 1890.
Chrysomphalus obscurus (Comst.). 1881.
Chrysomphalus tenebricosus (Comst.). 1881.
Cryptophyllaspis liquidambaris Kot. 1903.
Morganella maskelli (Ckll.). 1894.
Odonaspis inusitatus (Green). 1896.
Odonaspis penicillata Green. 1905.
**Pseudaonidia duplex* (Ckll.). 1896. Camphor Scale.
Pseudaonidia fimbricata (Mask.). 1892. On one slide the tarsi were apparently one-segmented.
**Rhizaspidiotus helianthi* (Parr.). 1899.

KERMESIDAE

**Capulinia salei* Sign. 1875.
Dactylopius confusus (Ckll.). 1893. Cottony Cochineal. Tarsal segments articulated.
Dastylopius confusus newsteadi (Ckll.). Articulated.
Dactylopius tomentosus (Lam.). 1835.
Eriococcus araucariae Mask. 1878. Apparently two-segmented.
Eriococcus ericae Sign. 1875.
Eriococcus quercus (Comst.). 1881.
Eriococcus smithi Lobd. 1930.
**Gossyparia spuria* (Modeer). 1778. European Elm Scale.

PSEUDOCOCCIDAE

Amonostherium lichtensioides (Ckll.). 1897. Tarsal segments articulated.
Ceroputo yuccae (Coq.). 1890. First tarsal segment sclerotized and articulated with second.
Ceroputo yuccae ceanothi Ckll. 1903. Distinctly articulated.
Ceroputo yuccae mexicanus (Ckll.). 1893. First tarsal segment heavily sclerotized and articulated with second.
Phenacoccus gossypii T. and Ckll. 1898. Tarsal segments articulated.
**Pseudococcus adonidum* (Linneus). 1762. Long tailed mealy bug.
Pseudococcus citri (Risso). 1813. Tarsal segments articulated.
Pseudococcus elizabethiae Brain. Apparently two-segmented tarsi.
Pseudococcus grandis (Hemp.). 1900.
Pseudococcus kraunhiae (Kuw.). 1902.
Pseudococcus lounsburyi Brain.
Pseudococcus natalensis Brain.
Pseudococcus nipae (Mask.). 1892.
Pseudococcus quaesitus Brain.
Pseudococcus stelli Brain.
Pseudococcus trichiliae Brain.
Trionymus jessica (Holl.). 1916.
Trionymus shaferi (Holl.). 1923.
Trionymus virgatus (Ckll.). 1893.
Ripersia confusella Ckll. 1902.
Ripersia sporoboli Ckll. 1902.
**Tetrura rubi* Licht. 1882.

MARGARODIDAE

Aspidoproctus maximus Lounsb. 1908.
Aspidoproctus mirabilis (Ckll.). 1902.
Callipappus australis (Mask.). 1890.
Coelostomidia wairoensis (Mask.). 1883.
Coelostomidia zealandica (Mask.). 1880.
Crypticerya rossae (R. and H.). 1890.
**Drosicha contrahens* Walk. 1858.
Drosicha corpulenta (Kuw.). 1902.
Drosicha howardi Kuw. 1922.
Drosicha mangifera (Green). 1904.
Drosicha pinicola Kuw. 1922.
Drosicha townsendi (Ckll.). 1905.
Drosicha haematoptera (Ckll.). 1919.
Echinocera anomola Morr.
Icerya euphorbia Brain.
Icerya montserratensis R. and H. 1890.
Icerya pilosa Green. 1896.
Icerya purchasi Mask. 1878. Cottony-Cushion Scale.
**Icerya sacchari* (Guerin) = *seychellarum* (Westw.). 1855.
**Labioproctus poleii* (Green). 1896.
Llaveia bouvari (Sign.). 1875.
Llaveia oaxacoensis Morr. 1927.
Margarodes papillosus Green. 1912.
Monophleboides gymnocarpi (Hall). 1926.
Monophlebulus comperei Morr. 1923.
Neosteingelia texana Morr. 1927.
Pseudaspidoproctus fulleri (Ckll.). 1901.
Ultracoelostoma assimile (Mask.). 1889
Xylococcus betulae Perg. 1898.
Xylococcus japonicus (Perg. 1898?).

In the *Diaspididae*, the most specialized of the coccids, two-segmented tarsi occur in the males of the two genotype species of its two oldest genera, *Diaspis* described by Costa in 1828 and *Aspidiotus* described by Bouche in 1833. In the subfamily *Aspidiotinae* not only the genotypes of its two oldest genera, *Aspidiotus hederae* (Vall.) 1829 and *Chrysomphalus aonidum* (Linn.) 1758, but also one or more other species representing three different lines of development in each of these genera, have males with two-segmented tarsi. In the subfamily *Diaspidinae* males with two-segmented tarsi occur in species representing at least twelve genera, four being genotype species. In this family with the exception of three species, two of which were described by the writer, all of the species listed have been known to science for more than a quarter of a century, and many have been considered pernicious pests for much longer periods.

Males with two-segmented tarsi are found in the family *Kermesidae* in such long known species as *Dactylopius tomentosus* (Lam.) 1835, *Eriococcus quercus* (Comst.) 1881, and *Gossyparia spuria* (Modeer) 1778.

The genotype species of the oldest genus of the family *Pseudococcidae*, *Pseudococcus adonidum* (Linn.) 1762 has males with two segments in the tarsi. *Pseudococcus citri* (Risso) 1813, and *Phenacoccus gossypii* T. and Ckll. 1898, two of the most serious mealy bug pests in greenhouses, have two segments in their tarsi.

Two segments have been reported for the anterior tarsi of females of *Ollifiella cristicola* Ckll.; however, I have not found in specimens examined (males were not available) any indication

of a division in any of the tarsi, while the tibio-tarsal articulation is less well developed than in some genera.

Although most of the male coccids which I have examined have wings, those specimens seen of the following species were wingless: *Comstockiella sabalis* (Comst.), *Halimococcus thebaicae* Hall., *Palmaricoccus attaleae* Stickney, *Palmaricoccus nesiotes* (Laing), *Phoenicoccus platanii* Ckll., *Platycoccus tylocephalus* Stickney, and *Stomococcus platani* Ferris. These wingless males have one-segmented tarsi and in *Halimococcus thebaicae* and *Platycoccus tylocephalus* the tibia and the tarsus are apparently fused.

In 1925 attention was called to the presence of rudimentary legs in a diaspidine, *Leucaspis knemion* Hoke, from Syria. Since then Dr. Fenner S. Stickney (1934) records the presence of rudimentary legs in the second stage female of *Parlatoria blanchardi* Targ. and Professor G. F. Ferris (1936) mentions that the second stage female of *Leucaspis candida* Targ. and the adult females of three species of *Lepidosaphes*, *Eerlaspis spinifera* (Mask.), *Opuntaspis carinata* (Ckll.), and *Opuntaspis philococcus* (Ckll.) have rudimentary legs. Five other species of *Lepidosaphes* in which the adult females have rudimentary legs might be added to the list of "exceptions" at this time. They are *Lepidosaphes calcarata* Ferris 1921, *L. chilopsidis* (Marl.) 1908, *L. javanensis* (Green) 1905, *L. nigra* (Ckll.) 1899, and *L. spinifera forma major* (Mask.) 1898.

THE BIOLOGICAL CONTROL OF INSECTS, With a Chapter on Weed Control, by HARVEY L. SWEETMAN, 1936. Pages i-xii+461, 142 figures. THE COMSTOCK PUBLISHING COMPANY, INC., Ithaca, New York. Price, $3.75.

The increasing number of examples of successful control of noxious insects by biological control methods has prompted several colleges and universities concerned with entomological training to offer courses in this promising field. Dr. Sweetman has been first to sift the enormous amount of scattered literature on biological control and has presented a timely and useful textbook. It is hoped that other workers will prepare similar books from time to time that will open up the field still further. As is to be expected in a general text where all phases of the problem are equally important, many things must be passed over rapidly. It is unfortunate in this case that the parasitic diptera and hymenoptera could not be treated more fully.

The book is in fourteen chapters, any of which may be omitted without affecting the continuity. Few references occur in the text, but the more important sources of material are arranged by chapters elsewhere in the book. Similarly, a glossary defines many terms not explained in the text.

Early history of biological control and the theoretical basis of the work are passed over rapidly with somewhat more space allotted to mathematical treatment of data. Separate chapters are devoted to the following natural enemies: bacteria and fungi, viruses and protozoa, roundworms, parasitic and predacious hexapods and vertebrates. Further treatment of many of these are received in chapters considering the utilization of insect predators and parasites and methods used in their introduction. The results of biological control experiments are summarized to the present.—B. J. L.

THE INTERNAL THORACIC SKELETON OF THE DRAGONFLIES

(ODONATA; SUBORDER ANISOPTERA)

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The dragonfly thorax has evolved from the generalized and primitive type of insect thorax along peculiarly specialized lines. The large flight muscles are associated with a mesothorax and a metathorax which are greatly enlarged and skewed so that the epimera and episterna slope backwards from the coxae towards the wing bases. (Needham and Anthony, 1903). This skewness has gone so far that the apparent top of the thorax is formed, not by the scutum, but by the side pieces, the episterna. As a result of the rearward crowding of the wings, these sclerites have expanded upwards and united along the mid-dorsal line in a carina that extends between the prothorax and the mesothoracic scutum. (Plate II, fig. 1). Similarly, much of the ventral side of the dragonfly thorax is formed, not of the sternum, but of the metathoracic epimera, which have expanded downwards and fused along the mid-ventral line, due to this same skewing process. Thus, in the dragonflies, the thorax is so constructed that the legs are crowded forward, close to the head, while the wings are pushed backwards. The first pair of wings usually lies above or behind the third pair of legs.

In spite of their great specialization the various parts of the dragonfly thorax have all been homologised with the thoracic parts of other insects (Plate II, fig. 1). An effort to trace the development of the thoracic sclerites of the adult dragonfly through the nymphal stages was made as follows: Using the method developed by Lew (1934) in studying dragonfly head characters, small scars were produced by pricking selected spots on the thorax with a fine, sharp needle. The location of the original scar was carefully noted, and any change in its shape or location immediately after ecdysis observed. These scars were clear and readily discernable in the nymphs, which carried them through several instars. They appeared as small brown spots. If there was any danger of their becoming lost, or indefinite, after several successive molts, they were re-pricked and so

made sharp and clear again. Nymphal scars carried through to the adult showed with great clarity against the pale green coloration of the teneral adults of *Anax junius* (Drury). This species was used in all of these experiments.

By these means it was hoped to determine whether the mesepisterna, in coming to cover the top of the thorax, did so by means of marginal growth, or by means of general expansion. Similar observations were made on the metepimera upon the ventral side. From observations made upon the developing thoraces of small nymphs, it was felt that the method of growth most likely to form the adult thorax from the nymphal one would be lateral expansion.

In small nymphs the structures noted as the nymphal carinae (Plate I, fig. 2) were observed to lie closely appressed. As the nymphs matured these carinae came to be separated by larger and larger areas of soft epidermis. Scar A was made in this nymphal carina, and scar B just next to it in the softer epidermis. (Plate I, fig. 5). These scars were easily seen, both in the nymph, and in the exuviae after molting. Thus the original position of the scar on the exuviae could be checked against its new position on the nymph after ecdysis. After molting, the nymphal crest, bearing scar A upon it, was observed to move farther away from the mesal line. (Plate I, fig. 2). This was interpreted to mean that growth was by means of marginal expansion of the thoracic plates. Had it been by a general expansion of the plates, this scar should have remained stationary, but enlarged in size. This, as will be shown later, did occur to some of the scars on the epimeron.

While the nymphal carina was changing its location in this fashion, bearing with it scar A, scar B, made just behind and almost under the caudal edge of the prothorax, moved away from its original location near scar A, and also away from the caudal edge of the prothorax. (Plate I, fig. 2). This was interpreted as meaning that when growth occurred it was by means of the expansion of all of the margins of all existing plates, not by the expansion of certain plates, nor by the expansion of certain margins of certain plates. In the last molt, from the nymph to the adult, the same marginal growth took place, but to a much more marked degree.

At first it seemed to be an obvious conclusion that the nymphal thoracic carinae and the antealar carinae of the adult thorax (Plate I, figs. 2 and 4), because of their somewhat similar

shape and location, were homologous. However, some doubt of this was felt when the nymphal cariane were observed to separate after molting. A test proved the correctness of this. The nymphal carina is a nymphal structure and leaves no mark upon the adult. Similarly, the ante-alar carina is an adult structure and has no origin in any external nymphal part. The black hairs which are present on it in the adult *Anax junius*, may be clearly seen through the nymphal skin shortly before the final molt takes place, but they do not lie under the nymphal carinae, and their is no external structure to indicate their presence. Scar A was made in the nymphal crest. It appears as scar A in the adult, centered on the smooth surface of the mesepisternum. Scar C, made on the smooth surface of the nymphal thorax where the presence of the ante-alar crest could be seen through it appears as scar C on the ante-alar crest of the adult. Thus these two structures seem to have nothing in common except their appearance and early location.

Scarring of the metasternum and the epimeron produced other results. No change in the shape of the metasternum was observed, but a great change in its location took place. It moved caudad through successive molts away from its normal position near the coxa, while the metepimeron expanded downwards to fill this space. In this spot there seems to be a general expansion of the epidermis in the last molt. Some of the scars placed here were noticed to expand greatly in size during the molt from nymph to adult, without changing their position. However, some of the scars did not change in size, but migrated caudad. This may have been due to individual variation on the part of the *Anax* nymphs, but it seems more likely that it was due to the impossibility of always placing the scars in exactly the same position on each nymph; so that both types of growth probably take place quite close together here. This is because the expansion of the metepimeron which crowds the metasternum back is the point of attachment for the principle depressor muscle of the hind wing. As this muscle is much smaller in the nymph than it is in the adult there must be a great expansion in size of both the muscle and its base during the last ecdysis. Since the general method of thoracic growth seems to be one of lateral expansion of the plates, it is very likely that lateral expansion may go on at the edge of the metepimeron at the same time that a local internal expansion goes on.

Scars made in the soft epidermis around the bases of the wings were difficult to follow, and did little except corroborate the observation that growth was by means of a general marginal expansion of the thoracic plates. These scars, due to the softness and wrinkling of the epidermis in which they were made tended to become easily lost.

In general, it may be said that while externally there is some resemblance between the nymphal thorax and that of the adult, and this resemblance may be traced and its analogies proved, internally there is little resemblance. The enlarged furcal plates and apodemes do not appear in the nymphal thorax at all. Only when the adult thorax is formed do they appear. They are adult structures, for which the nymph has no need, and they appear to be formed only of adult epidermis.

THE INTERNAL BRACING OF THE SYNTHORAX

The wing in dragonflies is a lever swinging upon a fulcrum formed by the end of the specially braced pleural apodeme. This apodeme extends upward from the heavily sclerotized furca which unites with the other furcae to form a sort of false floor to the thorax. This floor serves to divide the thorax into two compartments, a large upper one which houses the great muscles of the wings, and a much smaller lower one, into which are crowded the leg muscles. The wing muscles, the only ones with which this paper is concerned, are divided into two functional groups, the *elevators* and the *depressors*. These sets of muscles act alternately in the same direction. The elevators attach to the wing mesad of the wing fulcrum; thus on the up-stroke the wing becomes a lever of the first order, with the fulcrum between the power and the weight. The depressors lie laterad to the elevators and attach to the wings laterad to the wing fulcrum. This produces, on the down-stroke, a lever of the third order with the power between the fulcrum and the weight. By this arrangement the wings are raised and lowered by muscles which always act obliquely to the long axis of the thorax. In most other flying insects movements of the wings up or down are produced by sets of muscles which act in opposed directions.

The arrangement of the muscles and the fulcrum may be seen in the accompanying diagram of the apodemal bracing (Text fig. 1). This is a schematic representation, and includes only the flight muscles in order to avoid confusion.

In all animals, or machines, which use so tenuous a medium as air for a means of locomotion and support over prolonged periods of time are found extreme requirements for lightness and strength. The skeletons of dragonflies have undergone great changes to adapt them for that aerial existance to which they have become so well fitted.

The first and most obvious adaptation is the skewing of the flight segments, already mentioned, thereby making room for the wing muscles. The other great development is the formation of the four

large thoracic apodemes which serve as pivots for the wings, and as stiffeners for the otherwise thin-walled thorax. Connected to these apodemes are the heavily reinforced furcae to which the wing muscles find rigid attachment. From this furcal floor the apodemes run up to the wing bases as do the supports of a bridge.

There are several other braces which serve to stiffen the dragonfly thorax as well. The mid-dorsal carina, which runs up from the mesothoracic collar to the ante-alar carina, is one of the most prominent of these. (Plate I, fig. 4; Plate II, fig. 1.) The mesothoracic collar is a heavily sclerotized brace that curves up across the front of the mesothorax, joining together the stiffened margins of the mesinfraepisterna.

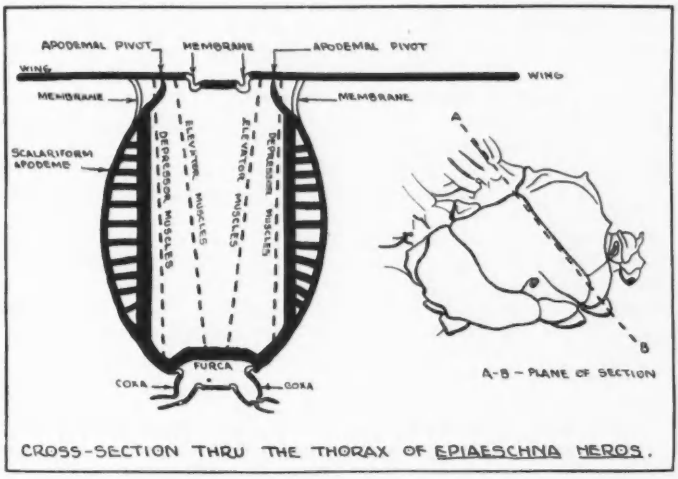

FIG. 1. Diagram of the apodemal bracing of the dragonfly thorax.

It serves as a basal support for the mid-dorsal carina. This carina appears to divide at its top, forming the laterally extending ante-alar carinae. Just behind this carina lies the ante-alar sinus, a groove between the ante-alar carina and the costal margins of the fore wings. Extending back from the ante-alar carina on each side of the thorax are the sub-alar carinae. These serve to mark the upper edges of the episterna, and by their thickening to increase the rigidity of the thorax.

An interesting feature connected with the peculiar functioning of the dragonfly wing is the great reduction in the size of the thoracic scutella. These are quite small, and they allow the wing bases to be very closely approximated along the mid-dorsal line of the back. This condition is nearly unique among flying insects. Usually the principal flight muscles attach to the scutella, which are consequently much expanded and strengthened, holding the bases of the wings far apart, as in bees, flies, etc.

The use of the pleural apodemes as wing braces and pivots is so peculiar to the dragonflies, and the development of them is so marked in these insects that this study of them was made to see what structural relationships exist through the different families and genera, and to see if any evolutionary steps in the formation of these structures could be found. The material at hand for study was largely North American.

The musculature of the dragonfly thorax is unique among insects, and the skeleton which supports these muscles is equally unique. The functional endoskeleton is formed around the meso- and metathoracic apodemes and the meso- and metathoracic furcae as principal elements. According to Snodgrass (1935), these furcae in a typical insect thorax serve as attachments for the principal longitudinal muscles. These muscles are greatly reduced or lacking in the dragonflies, and the meso- and metathoracic furcae serve chiefly as attachments for the oblique wing muscles. The principal apodemes have no muscle attachments that could be observed in the adult, but seem to serve as reinforcing braces to the thoracic walls, and as fulcral points upon which the wings operate. The general form of the furcae appears to be quite uniform throughout the entire suborder, being a sort of secondary floor to the thorax. The apodemes, on the other hand, show some very distinct variations, and so it was to them that attention was directed.

These apodemes are formed upon the meso- and metathoracic pleural sutures, which, due to a very deep infolding of the cuticula here, are very clearly marked upon the external surface. The true intersegmental sutures, having no such cuticular infolding, are quite inconspicuous. The apparent segmentary sutures of the dragonfly thorax are thus not *intersegmentary*, but *intrasegmentary*.

Snodgrass (1935) defines an apodeme as a cuticular ingrowth of the body wall. In the dragonflies the apodemes appear to be not *ingrowths*, but *infoldings*. Boiling in potash (KOH, 10% solution) causes the two sides of the apodeme to separate, very much as the folded pages of a letter separate, without injuring either side. Whenever the sides of a cross-barred apodeme were separated, the cross-bars were invariably found to be on the caudal side of the fold. In life both sides of the apodeme are so firmly joined together that it is impossible to separate them.

In general the form of the meso- and meta-thoracic apodemes is somewhat similar to the structural steel I-beam. It is usually thickened along each edge, with a thinner membrane always connecting these edges.

This I-beam type of apodeme in dragonflies varies in two directions. In the *Aeschnidae* is developed what I have termed the *scalariform type* of apodeme, due to its fancied resemblance to a ladder. This type of apodeme is characterized by the development of thickened cross-bars which run between the reinforced margins of the structure, and between which the wall of the apodeme is quite thin. While the individual apodemes are ladder-like in form, a glance into the thorax with them all in place and connected with the furcae, shows an assemblage of struts and braces which looks startlingly like the framework of a steel bridge. Because of the great development of this

structure in the *Aeschnidae* this group was studied to see if its origin and development could be determined. This work was done with the genera *Aeschna*, *Anax*, and *Epiaeschna*.

The *Libellulidae* possess no cross-bar structures at all in this I-beam apodeme. Instead, the inner margin of the apodeme tends to be very heavily reinforced, and the mesopleural suture is S-shaped. This was first pointed out by Garman (1927).

Aside from these two very marked differences in the apodemes, the thickness and the degree of their extension into the thorax seem to correspond to the powers of flight of the dragonfly in question. As a rather general rule, the more powerful and continuous a flyer a dragonfly is, the more strongly developed will its thoracic apodemes tend to be.

EPIAESCHNA HEROS

(Plate II)

In order to understand the structures with which this paper deals, the following brief description of the apodemes and furcae is made for a single species. Details will differ in other species, but there is one general plan.

The furcae of the thorax are heavily sclerotized, more or less fused, and joined to the floor of the thorax in three places by a sort of bridge which extends laterally between the furcae and the metinfraepisterna, called here the *furcal bridge* (Plate II, figs. 2 and 3), and by a vertical support which extends to the mid-ventral line between and behind the metacoxal cavities. Both the meso- and metathoracic furcae appear to be fused together and serve as points of attachment for the principal elevator muscles of the wings.

The apodemes do not extend directly to the furcae, but branch around the infraepisterna. The mesothoracic apodeme branches at the mesinfraepisternum. One branch extends forward and forms a broad base for the forward accessory depressor of the fore wing; at this point it turns abruptly backwards, joining the branch from the other side on the mid-ventral line, just between the meso- and metacoxae, and extends back to the intersegmental suture. From this point a strongly sclerotized brace extends upward along this suture until it reaches the level of the metathoracic spiracle. Here it ends. To it is attached the tendon of the acetabular muscle.

The other branch of the mesothoracic apodeme extends downward and backward to this intersegmental brace, just in front of the hind margin of the metathoracic coxa. Just below this junction the furcal bridge arises. On the distal side of this branch of the mesothoracic apodeme is a heavily sclerotized region to which the base of the principal depressor muscle of the fore wing attaches. These two branches of the mesothoracic apodeme form a sort of a rectangular brace which is attached to the furcae near one corner by the furcal bridge.

The metathoracic apodeme branches similarly around the metinfraepisternum. The anterior branch extends rather directly down to the junction of the furcal bridge and the intersegmental apodeme. Between

the bridge and the mid-ventral line it unites with the intersegmental apodeme, after first paralleling this structure for a short distance.

The posterior branch is broadened on its distal side, thus providing attachment for the base of the principal depressor muscle of the hind wing. This branch extends backward beyond this muscle, and then turns inward to unite with the same branch of the apodeme from the other side upon the mid-ventral line. Here a central sclerotized support serves to unite these two branches of the metathoracic apodeme with the caudal end of the furcae. They serve to form a sort of warped triangular brace for the base of the metathoracic apodeme, which unites with the furcae at the apodemal bridge and on the mid-ventral line just behind the metacoxae.

From the metathoracic apodeme, just above the metinfraepisternum, a short sclerotized rod extends forward, towards, but not touching, the metathoracic spiracle. What function this has, if any, is not apparent.

Two rather large sclerotized tendons extend from the caudal end of the furcae, forming the attachments of the auxiliary sterno-dorsal muscles. These muscles are supposed to serve in elevating the abdomen.

From the infraepisterna the apodemes extend up rather directly to the bases of the wings, where there is an uneven T-shaped expansion (Snodgrass, 1909). The short arm of this T-shaped process, which extends forward, serves as a support for the costal wing vein. The longer arm, extending rearward, supports the radius and media veins. These unite in the base of the dragonfly wing to form a single heavy vein. No apodemal support for the cubital vein was observed. The dorsal ends of both apodemes appear to be quite alike in structure. Sometimes one may be more strongly developed than the other, as in some of the *Libellulidae*, but there is otherwise little difference.

This description has dealt with the general form of the dragonfly apodemes, as illustrated by *Epiaeschna heros*, and their relation to other skeletal and muscular parts. The actual modifications of the apodemes themselves, the scalariform structure, and the sigmoidal curving of the mesopleural suture, follow. It may be said that the various modifications of the apodemes have no effect upon their basic relationships.

DISCUSSION BY GROUPS

1. *Cordulegasterinae.*—The apodemes of *Cordulegaster* exhibit no scalariform structure, although they are quite well formed and thickened along both margins, and there is no tendency toward a sigmoidal curving of the mesopleural suture.

2. *Aeschninae.*—The apodemes are well developed and exhibit considerable variation in scalariform structure. Those of *Gomphaeschna* and *Basiaeschna* lack a scalariform structure altogether, as do *Oplonaeschna* and *Nasiaeschna* higher up in the series. In *Boyeria* only the metathoracic apodemes are scalariform, with considerable variation in the number of the cross-bars. The apodemes of *Anax*, *Coryphaeschna*, *Epiaeschna*, and *Gynacantha* all have a uniformly developed scalariform structure. In *Aeschna* there is a great variation in the number of the cross-bars in different species of the genus, and even among different individuals of the same species. The presence of accessory bars, or

cross-bars which do not completely span the apodeme, is rather characteristic of this subfamily; they are found in *Coryphaeschna*, *Aeschna*, and *Gynacantha*. Occasional individuals of some species of *Aeschna* show a slight tendency toward a curving of the apodeme crossbars, but never to the extent to which this occurs in the Gomphines. Caudad offsetting of the distal ends of the cross-bars is also very slightly marked in the Aeschnines, occurring only in *Anax* and *Epiaeschna*. In *Anax* only the mesothoracic apodemes, and in *Epiaeschna* only the metathoracic ones, show this offsetting. The mesopleural suture extends directly up to the wing bases, without any indication of a sigmoidal curve. With the exception of *Nasiaeschna*, which seems to stand in the Aeschnines in the same position that *Lanthus* stands in the Gomphines with respect to apodemal development, the apodemes are all well developed. The inner edge is usually quite strongly reinforced, and the outer edge, along the pleura, is apparently strengthened also. The part of the apodeme between these margins is usually quite thin, in contrast to the thicker apodemes found among the Libellulines.

3. *Gomphinae*.—The apodemes are well developed in most species, exhibiting the scalariform structure with remarkable uniformity throughout the different genera. Representatives of all North American genera, excepting *Erpetogomphus*, were examined, and all were found to possess this structure. Accessory cross-bars, or cross-bars which do not extend completely across the apodeme, were found only in *Progomphus*. These are more characteristic of the Aeschnines. Caudad offsetting of the distal ends of the cross-bars is characteristic of the Gomphines, only *Aphylla*, *Lanthus*, and *Octogomphus* lacking it completely. The number of complete cross-bars varies from seven to eleven on the mesothoracic apodeme, and from five to nine on the metathoracic apodeme. Sometimes (*Gomphoides*, *Aphylla*, *Ophiogomphus*, and *Octogomphus*) the cross-bars are curved instead of extending straight across; this character is almost wholly limited to the Gomphines, although *Aeschna* sometimes shows a slight tendency in this direction. The mesopleural suture extends nearly straight up from the mesinfraepisternum to the wing base, and exhibits none of the sigmoidal curving which is characteristic of the *Libellulidae*. The apodeme follows the suture on the inside of the thorax, and its inner margin is usually thickened. There is usually not much thickening along the pleural suture, but the external ends of the cross-bars are often bent in a caudal direction, forming an L-shaped brace. When there is a marked caudad offsetting of the distal ends of the cross-bars this angle is not well developed, but the space between the bar and the apodeme is strongly sclerotized, forming a triangular instead of an L-shaped brace. Only *Lanthus*, a weakly flying dragonfly, has the apodemes weakly developed.

4. *Macromiinae*.—The scalariform structure of the apodemes is absent in this and other groups of the *Libellulidae*. The apodemes are all well developed, and there appears to be a thickening of the epidermis along the pleural suture, which serves to brace the apodeme along its outer margin. The sigmoidal curving of the mesopleural suture, so characteristic of the *Libellulidae*, is apparent in a slight curving of this structure.

5. *Cordulinae.*—The Cordulines parallel the Macromiines in the development of the thoracic apodemes. The Cordulines are a somewhat larger group, and not all of the genera were examined. However, all of those examined showed a rather uniform development of this structure. All except *Epicordulia* lacked any noticeable thickening along the pleural suture, but the inner edge of the apodeme was always stoutly reinforced. This was particularly so in *Tetragoneuria*. The sigmoidal curving of the mesopleural suture is only moderately developed.

6. *Libellulinae.*—There is no trace of scalariform structure in the apodemes in this group. It is here that the sigmoidal curving of the mesopleural suture becomes most strongly marked. The apodemes are all well developed but unbraced along the outer margins. The sclerotized thickening along the pleural sutures appears to be rather irregular, but is more common along the metapleural than along the mesopleural suture. The inner margins of the apodemes are always heavily reinforced. Sometimes this thickening of the inner margin of the apodeme extends completely out to the pleural suture and appears to fuse with it. Throughout the group there appears to be a strengthening of the metathoracic apodemes. There is, in fact, a remarkable uniformity of apodemal development throughout this subfamily.

DISCUSSION

The scalariform type of apodeme and the sigmoidal curving of the mesopleural suture are distinct structural adaptations in the Anisoptera. Either, or neither, may be present, but never both. The Anisoptera may be divided into five groups according to their thoracic apodemal development:

1. The *Cordulegasterinae*, in which scalariform apodemes are not present, and in which there is no sigmoidal curving of the mesopleural suture. This group appears to be a basic one as far as these structures are concerned.

2. The *Aeschninae*, in which the scalariform structure of the apodeme appears to be undergoing a formative process, and is subject to great variation. No sigmoidal curving of the mesopleural suture occurs in this group.

3. The *Gomphinae*, in which the scalariform type of apodeme strongly developed and uniform throughout the group. There is no sigmoidal curving of the mesopleural suture in this group.

4. The *Macromiinae* and the *Cordulinae*, in which the sigmoidal curving of the mesopleural suture appears. In neither is it as marked as it becomes in the following subfamily, but all genera and species show it. The apodemes are well developed, but show no trace of the scalariform structure.

5. The *Libellulinae*, in which the sigmoidal curve of the mesopleural suture is most markedly and uniformly developed. There is no indication of a scalariform structure. The inner margin of each apodeme is unusually strengthened, and the metathoracic one usually markedly so.

These five groups seem to illustrate a divergent evolution of internal skeletal structures. Starting with a basic group, the *Cordulegasterinae*, in which the apodemes, although strongly formed, show no great structural specialization, two distinct

lines of development may be followed. In the *Aeschninae* the formation of a scalariform apodeme begins. This type of apodeme is lacking in the primitive genera of the subfamily, but becomes well developed among some of the more advanced genera. Throughout the group, however, it shows considerable tendency to vary. In the *Gomphinae* it becomes strongly developed, with little tendency to vary. The Gomphines may, in all probability, be considered as representing the peak of the scalariform development of the apodemes among existing dragonflies.

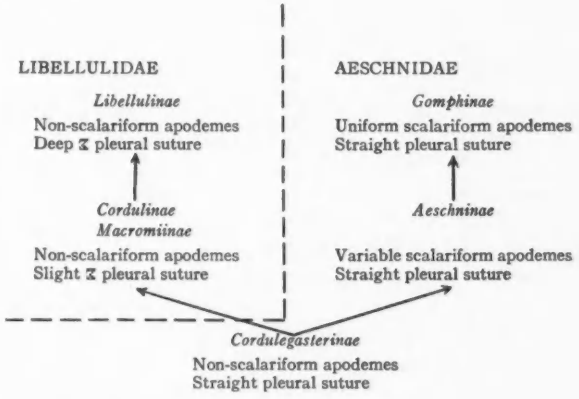

FIG. 2. Diagram of the changes in apodemal form in the dragonfly thorax.

Among the Cordulines and the Macromiines specialization has begun along another line. There are no scalariform thickenings of the apodemes, but the beginning of a sigmoidal curving of the mesopleural suture. In the Libellulines this curving becomes very great, and the internal margins of the apodemes, particularly of the metapleural apodeme, become heavily reinforced. They exhibit no scalariform structure. The Libellulines would seem, therefore, to represent the peak of the development of the sigmoidal curving of the mesopleural suture at the present time. On the whole, there seems to be less variation in the developing of this sigmoidal curving of the mesopleural suture than in the development of the scalariform apodeme. Just why this should be is not apparent.

THE ORIGIN OF THE SCALARIFORM APODEME

The scalariform apodeme seems to be entirely an ingrowth of the adult exoskeleton and does not appear in the nymphal thorax at all. It can be found there only when the adult thorax at all. It can be found there only when the adult thorax is fully formed inside the last nymphal one, and then it is within the adult thorax, rather than the nymphal one. Examinations of the exuviae of nymphs from which the adults had emerged showed no trace of it, and dissections of nymphal thoraces were equally fruitless.

Phylogenetically there is no direct evidence for the origin of this structure. It appears to be best developed in what is ordinarily thought of as the lowest subfamily, and disappears among the higher ones.

In the group where there would seem to be the greatest need for lightness and strength, the *Aeschninae*, the scalariform apodeme is poorly developed. Similarly, the development of the sigmoidal curving of the mesopleural suture appears to be independent of structural needs, for it is accompanied by a loss of sclerotization of that suture.

The formation of the cross-bars in the scalariform type of apodeme may be similar to the formation of the veins in an insect wing, i. e., sclerotization along certain, localized lines. There are no tracheae in the apodemes to govern the localization of such lines, but such may be a likely hypothesis. The presence of accessory cross-bars in the apodemes of *Aeschna* would seem to corroborate this.

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EXPLANATION OF PLATES

PLATE I

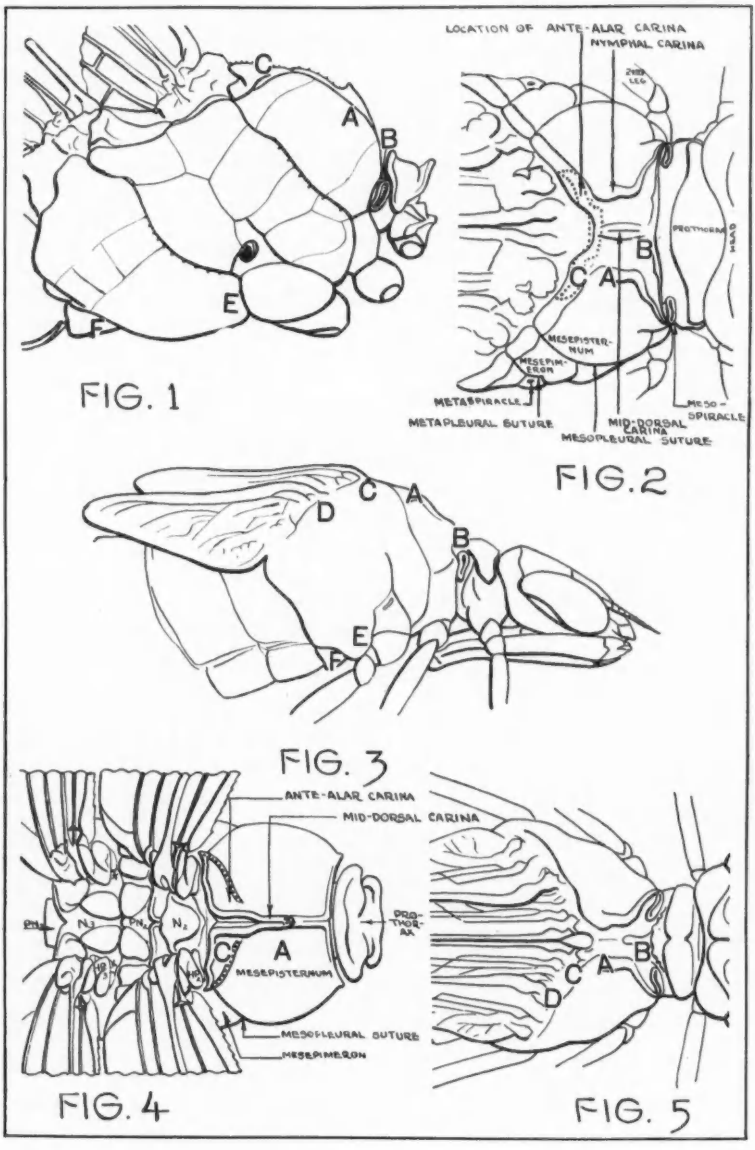
Anax junius (Drury)

Fig. 1, Thorax of adult, lateral view. Fig. 2, Thorax of mature nymph, dorsal view. Fig. 3, Thorax of nymph, lateral view. Fig. 4, Thorax of adult, dorsal view. Fig. 5, Thorax of nymph, dorsal view. A, B, C, D, E, F, scar points; PN: Post-notum; N: Notum; HP: Humeral plate. Subscript numerals refer to the meso- and metathorax.

PLATE II

Epiaeschna heros (Fabr.)

Fig. 1, Thorax of adult, external lateral view. Fig. 2, Thorax of adult, internal lateral view. Fig. 3, Dorsal view of the floor of the thorax, made along line A–B, Fig. 2. A–B: plane of Fig. 3; AC: acetabular tendon; AD: base of accessory depressor muscle; ASD: auxiliary sterno-dorsal tendon; BR: furcal bridge; PD: base of principal depressor muscle; PE: base of principal elevator muscle. Subscript numerals refer to the meso- and metathorax.


C
A
B
E
F
FIG. 1
LOCATION OF ANTE-ALAR CARINA
NYMPHAL CARINA
2ND LEG
PROTHORAX
HEAD
B
C
A
MESEPISTER-NUM
MESEPIM-ERON
METASPIRACLE
METAPLEURAL SUTURE
MID-DORSAL CARINA
MESOPLEURAL SUTURE
MESO-SPIRACLE
FIG. 2
D
C
A
B
E
F
FIG. 3
ANTE-ALAR CARINA
MID-DORSAL CARINA
PRO-THOR-AX
A
MESEPISTERNUM
MESOPLEURAL SUTURE
MESEPIMERON
FIG. 4
C
A
B
D
FIG. 5

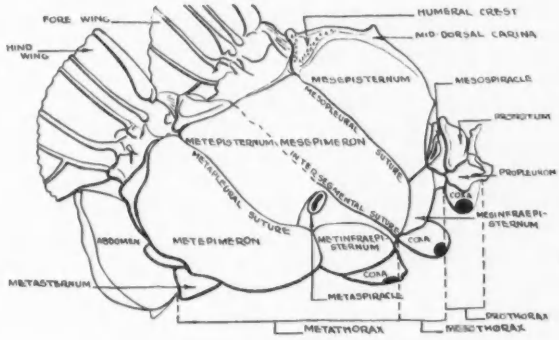


FIG. 1.

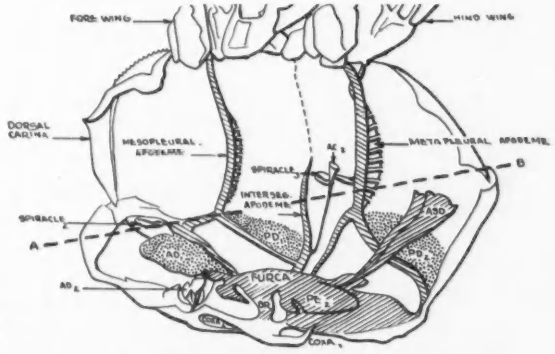


FIG. 2

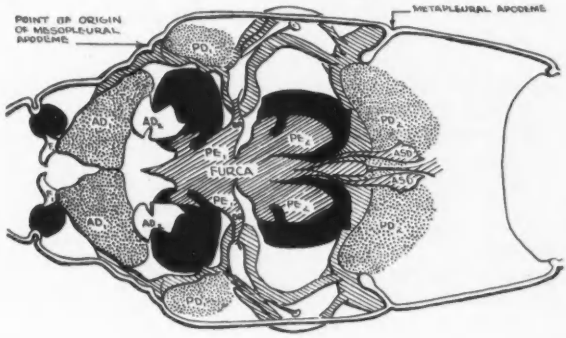


FIG. 3

BIOLOGY OF THE BORDERED MANTID, STAGMOMANTIS LIMBATA HAHN (ORTHOPTERA, MANTIDAE)

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The bordered mantid, *Stagmomantis limbata* Hahn, is more restricted in its range than is *S. carolina* Johan. The latter species may be collected from the Atlantic Coast to California and as far north as Colorado, Missouri, Illinois, and southern Pennsylvania, but *S. limbata* has been found only in Mexico, Arizona, New Mexico, and Texas. These two species, although separated by very distinct structural characters, are similar in appearance and habits.

Stagmomantis limbata was first described in 1836 by Carl Wilhelm Hahn (2). The few references to the insect in literature pertain mainly to notes on distribution. Hunter and Hinds (3), in 1905, noted the presence in Texas of the mantid on cotton plants, where it fed to some extent on the boll weevil, *Anthonomus grandis* Boh.

In March, 1932, a number of egg cases of *Stagmomantis limbata* were received from Superior, Ariz., where they had been collected in the field. Nymphs from these eggs were reared to maturity in 1932, and the strain was continued until 1934. All the breeding work was done at Uvalde, Tex., in an outdoor insectary.

EGG CASE

The egg case of *Stagmomantis limbata* is readily distinguished from that of *S. carolina* by differences in color and shape. The egg case of *S. limbata* is a much richer brown, varying from a reddish chocolate brown to a lighter yellowish brown with reddish tinge, in contrast to the duller buff brown egg cases of *S. carolina*. A whitish streak is present down the crest line from end to end; this covers the egg-chamber exits, and after the nymphs hatch much of the white disappears. Sometimes a whitish streak is found on the side of the egg case, running from end to end. The case has the same braided appearance as those of other mantids. The shape of the egg case tends in all ways to be more rounded

[1]The author is indebted to the late A. N. Caudell and to C. F. W. Muesebeck for determination of material; to J. A. G. Rehn for suggestions and criticisms of the work; to V. Curtis for securing the original lot of specimens, and to Ralph Connor for assistance in feeding and rearing the insects.

than that of *S. carolina*. The base, when the egg case is attached to a flat surface, forms an elongated oval; whereas in *S. carolina* the sides of the egg case tend to run parallel until near the ends, where they meet rather abruptly in a blunt point. From crest to base the surface curves roundly, in contrast to the flattened egg case of *S. carolina*. The roundness (not lengthwise) is particularly emphasized in egg cases from Arizona, where *S. limbata* appears to have the habit of attaching the egg case to the stem (about 1.5 mm. in diameter) of a thorny bush; this reduces the base of the egg case and further curves the sides.

The egg case of *Stagmomantis limbata* is approximately the same length as that of *S. carolina*, but it exceeds it slightly in breadth and considerably in height. Twenty-one egg cases collected in nature in Arizona averaged 19.3 mm. in length, 11.5 mm. in breadth, and 10.0 mm. in height; maximum, 27 mm. long, 13 mm. broad, and 12 mm. high; and minimum, 14 mm. long, 10 mm. broad, and 9 mm. high. At

TABLE I

AVERAGE MEASUREMENT OF NYMPHS OF *Stagmomantis limbata*.
(Instars Indicated by Roman Numerals)

	I	II	III	IV	V	VI	VII	VIII
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Width of head	1.60	1.93	2.42	2.90	3.53	4.55	5.07	6.25
Greatest width of pronotum	0.75	0.78	1.00	1.45	1.60	2.19	2.87	3.40
Length of body including head	7.10	8.90	11.00	15.30	18.30	25.17	28.30	34.00
Length of pronotum	2.20	2.80	4.00	4.80	6.33	8.32	10.20	12.60
Length of cephalic femur	2.10	2.20	3.00	3.50	4.83	6.38	7.67	9.55

Uvalde, egg cases of *S. carolina* average 19.4 mm. in length, 10.6 mm. in breadth, and 6.5 mm. in height; these figures check with those of Didlake (1): 20 mm. long, 10 mm. broad, and 7.5 mm. high.

Egg cases of *Stagmomantis limbata* deposited by females in captivity were normal except that they were shorter than those collected in nature, the average length being only 14 mm. As these egg cases were deposited on flat surfaces they were also broader but not so high as those deposited on bushes.

NYMPHS

Table I shows the measurements of the nymphal instars of *Stagmomantis limbata*. Reference to it will indicate the proportionate changes in size during the period of growth.

The first-instar nymphs have a body color of pale transparent green, the tip of the abdomen being sometimes yellowish, and there being faint brownish markings along the median line of the thorax; the eyes are darker green, pigmented beneath, the antennae appear brownish, and

the tips of the mandibles are brown; the forelegs are green, the spines brown, and there are two brownish-black spots on the inside surface of the femur; the middle and hind legs are green with the tarsi brownish.

The second-instar nymphs are pale green but have lost the transparency of the first instar. The yellowish-green legs are more or less banded with brown at the juncture of the tibiae and tarsi, and the distal tarsal segments are brownish. Three brownish-black spots are now visible on the inside surface of the femur.

During the third stadium a difference in the color of the mantid nymphs is apparent. This difference becomes more pronounced through the fourth and fifth stadia, and persists until the nymphs mature. Two main color phases develop, a green and a buff; in these, however, there are many variations and gradations into one another.

In the seventh instar the two color phases may be described as follows: One is a green which varies from light to intense, almost jade green. The body is marked with brown in varying intensities. Usually the pronotum is strongly marked around the edges with brown. Brown also appears on the developing wings, and the legs are banded more or less indistinctly with brown. In nearly every instance the two basal abdominal segments are brown dorsally, often of a rich reddish hue. In most instances the furrow of the forelegs, together with the claws and spines, is very brown. The other form is a pale buff varying to green, often with a rather powdery effect. These color forms vary from lightly mottled with gray to strongly banded and mottled with gray and brown.

The male nymphs are usually green, but the female nymphs are divided about equally between the two color phases.

Development of the wing pads is evident from the second stadium if the nymph is closely examined with a lens. From the fourth stadium development is plainly evident, and at this time the sex of the nymphs may be determined, the wing pads of the males being more extended posteriorly and laterally.

Both male and female first-instar nymphs have eight abdominal segments ventrally; during the second stadium the sixth abdominal segment of the female appears cleft apically; during the following stadia the seventh and eighth ventral segments are modified until they are hidden by the sixth, which appears as the terminal cleft segment in the adult. During the fifth stadium and those following, the sex is easily distinguishable by the appearance of the six ventral segments in the female and eight in the male.

ADULT

Male.—Color: Body green, posterior two-thirds of pronotum marked with brown; tegmina translucent green, anterior third brownish with marginal field green, tips of tegmina sometimes brown, stigma deep brown; head green, antennae greenish brown, eyes green; legs green, spines brown, juncture of segments often brown. Although two color phases have been recorded for the males, only the green form was observed by the author.

Measurements: Length of body including head 54 mm., greatest width of head 8.5 mm., greatest width of pronotum 3.3 mm., length of

pronotum 16 mm., length of tegmen 35 mm., length of cephalic femur 11 mm., breadth of cephalic femur 1.7 mm.

Female.—Color: In green phase, body bright green to jade green, occasionally the posterior third of pronotum shaded with brown; tegmina green, not translucent, stigma white; head green, antennae brownish green, eyes green; legs green, spines brown.

In brown phase, body varying from straw color to gray, mottled and stippled with brown and smoky gray; tegmina yellowish brown, often mottled, stigma brown; head brown, antennae brown, eyes gray, sometimes pink, legs light brown, marked with darker color. The brown color of this phase often changes to gray by the end of the season.

Measurements: Length of body including head 53 mm., greatest width of pronotum 4.8 mm., length of pronotum 20 mm., length of tegmen 23 mm., length of cephalic femur 14.5 mm., breadth of cephalic femur 4 mm.

TABLE II

WEATHER RECORDS SHOWING MEAN TEMPERATURE, MEAN HUMIDITY, AND PRECIPITATION, UVALDE, TEXAS, 1932, 1933, AND 1934

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
						Mean Temperatures (°F.)							
1932.....	54.9	61.5	58.8	71.0	75.9	84.4	82.4	83.8	76.1	67.3	55.5	50.1	68.50
1933.....	57.1	53.8	65.0	70.2	79.7	80.7	86.3	85.0	83.8	75.9	64.2	60.1	71.82
1934.....	55.0	56.5	60.5	72.6	77.4	85.7	85.6	81.8	81.2	75.9	66.2	55.0	71.12
						Mean Humidity (Percent)							
1932.....	65.7	70.0	57.1	59.7	66.1	63.0	67.2	66.5	72.6	65.8	59.7	73.6	65.58
1933.....	66.6	63.8	62.1	54.3	63.7	58.6	58.9	62.2	63.4	60.7	61.4	58.5	61.18
						Precipitation (Inches)							Total
1932.....	0.6	1.6	1.4	1.7	2.0	1.0	20.5	3.5	10.8	0.2	0.8	1.2	45.30
1933.....	2.7	1.7	.2	.7	2.8	.8	1.3	1.4	1.1	1.3	.3	.4	14.70
1934.....	2.9	.2	.9	1.3	1.9	.2	3.6	.4	1.3	.4	.5	2.5	16.10

METHODS IN STUDY OF BIOLOGY

During the rearing of the mantids each egg case was placed separately in a glass vial (1 by 4 inches) with cork stopper. The egg case remained there over the winter and until hatching occurred. When the nymphs hatched each was placed separately in a glass vial. They were fed daily on living insects, but no water was furnished. A daily record was made of each nymph, showing data concerning feeding, molting, injuries, etc. Following the third molt the nymphs were placed each in a pint mason jar with lid of 60-mesh brass strainer cloth. A stick, an inch wide and 5 inches long, provided a climbing place for the insects, and to it the egg cases were attached. All the living material was kept in a screened insectary at outdoor temperatures. All the data pertaining to the rearing of these mantids were secured under laboratory conditions, as *Stagmomantis limbata* has not been collected by the writer in the field at Uvalde, Tex. Only the original collection of specimens at Superior, Ariz., was under natural environment.

TABLE III

SUMMARY OF DEPOSITION AND HATCHING OF EGGS OF *Stagmomantis limbata* FROM 1931 TO 1934, UVALDE, TEXAS

Year Eggs Deposited	Females	Egg Masses	Range of Egg-laying Period	Range of Hatching Period	Nymphs Hatched					Incubation Period		
					Total	Average per Egg Mass	Maximum per Egg Mass	Average per Female	Maximum per Female	Minimum	Maximum	Range of average periods for all Egg Masses each year
	Number	*Number*			*Number*	*Number*	*Number*	*Number*	*Number*	*Days*	*Days*	*Days*
1931–1932*	.....	7	.....	Apr. 18 to May 6	454	65	131	.....	.....	.....	.....	.....
1932–1933	5	15	Aug. 26 to Dec. 3	Mar. 20 to May 7	741	49	79	148	282	147	216	147–209
1933–1934	2	12	Sept. 2 to Nov. 29	Mar. 2 to Apr. 19	510	43	73	255	326	140	210	142–205
Summary	7	34	Aug. 26 to Dec. 3	Mar. 2 to May 7	1,705	50	131	179	326	140	216	142–209

*Eggs collected in field; exact date of deposition, number per female, etc., unknown.

TEMPERATURES AND MOISTURE

The rearing of nymphs of *Stagmomantis limbata* was done during 1932, when the average mean temperature for the year was approximately 1.82 Fahrenheit degrees below normal, the mean relative humidity 3.31 percent above normal, and the mean rainfall 21.10 inches above normal, and in 1933, when the average mean temperature was 1.5 Fahrenheit degrees above normal, the mean relative humidity 1 percent below normal, and the mean rainfall 9 inches below normal. In Table II are listed the mean temperature, humidity, and precipitation for Uvalde, Tex., for 1932 to 1934. Reference should be made to these records in studying the hatching, developmental period of the nymphs, etc.

NUMBER OF GENERATIONS PER YEAR

As indicated by the number of days required for *Stagmomantis limbata* to reach maturity and by the fact that the insect was found hibernating in the egg stage, we may conclude that this mantid produces but one generation each year.

PRODUCTION OF EGG CASES

The number of egg cases produced by a single female of *Stagmomantis limbata*, the number of eggs per case, and the interval between the production of cases are influenced by the environment of the female and the amount of food obtainable, as well as by her association with a male.

Table III gives a summary of the records of 34 egg cases deposited over a period of 3 years.

It will be seen from Table III that the egg cases collected in the field produced considerably more nymphs per mass than did those deposited and held under laboratory conditions. There are two probable reasons for this. Females in nature have more difficulty in securing food; therefore, they retain their egg masses longer and deposit more ripened eggs at once. In captivity the females lay more frequently but deposit smaller masses. This was shown to be true by actual measurement. The second reason is that the unnatural environment, particularly low humidity, causes a decrease in the numbers of nymphs hatching.

From data at hand it may be said that a single egg mass may produce as many as 131 nymphs and a single female as many as 326 viable eggs. In 1932 the females laid on an average 3 egg masses at average intervals of 22 days, while in 1933 an average of 6 was laid at average intervals of 14 days. These averages were substantiated by production of eggs from numerous other individuals not shown in the table. However, the average number of nymphs produced by each egg mass for these 2 years was about the same. The maximum number of egg masses produced by a female was 7, one of which was infertile. The minimum interval between deposition of fertile egg masses was 11 days and the maximum 33 days.

TABLE IV

SUMMARY SHOWING AVERAGE LENGTH OF THE NYMPHAL STADIA OF *Stagmomantis limbata*, UVALDE, TEXAS, 1932–1933

	I		II		III		IV		V		VI		VII		VIII		IX	
	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium	Nymphs	Length of Stadium
	Number	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*	*Number*	*Days*
1932. Nymphs that reached maturity	37	17.5	37	12.3	37	10.1	37	9.4	37	12.6	37	14.0	37	14.0	35	17.0	18	17.9
1932. Died as nymphs	20	18.9	20	12.1	20	9.8	19	10.4	14	13.5	7	13.7	4	16.3	.....	.....	.....	.....
1933. Nymphs that reached maturity	23	15.2	23	8.4	23	9.0	23	10.1	23	14.3	23	15.3	23	14.4	23	16.3	12	19.9
1933. Died as nymphs	29	14.9	25	8.6	23	9.3	22	9.6	21	14.2	15	13.8	7	14.7	4	16.8	.....	.....
Total or Average	109	16.6	105	10.5	103	9.6	101	9.8	95	13.5	82	14.3	71	14.3	62	16.7	30	18.7

The incubation periods of the eggs were about the same for both years, the minimum being 140 days, the maximum 216 days, and the range of averages 147 to 209 days. The earliest date for deposition of an egg case was August 26, 1932; the latest, December 3, 1932.

A female, mated 5 days after maturity with a male that was 9 days old, produced fertile eggs 15 days later. This period of 20 days was the minimum period recorded from maturity of female to oviposition. Copulation lasts 4 hours or longer, and the female usually eats the male unless he is lucky enough to escape. Unmated females, when mated about 50 days after emergence, would frequently produce on the following day an egg case containing fertile eggs. Unmated females on an average did not begin to produce egg masses (infertile) until about 65 days after maturity, although a minimum period of 36 days was recorded. Unmated females produced about the same number of egg cases as the fertilized ones.

LENGTH OF NYMPHAL STADIA

Two generations of *Stagmomantis limbata* were reared, one in 1932 and the other in 1933. In 1932 an experiment was started with 117 newly hatched nymphs; of these, 60 died before reaching the fourth instar. In Table IV the lengths of the stadia are presented for the remaining 57, although 20 of these died before reaching maturity. Of the 37 matured mantids (32 percent of original number) 17 were males and 20 females. Seven to 9 molts were required for maturing. These, summarized by sex, were as follows: Males, 2 in 7 instars, 12 in 8 instars, and 3 in 9 instars; females, 5 in 8 instars and 15 in 9 instars.

In 1933 an experiment was begun with 63 nymphs, 11 of which died before reaching the second instar. The lengths of the stadia are given for the remaining 52. Twenty-nine died before reaching maturity. Of the 23 mantids (37 percent) that matured 12 were males and 11 females. These matured as follows: Males, 9 in 8 instars and 3 in 9 instars; females, 2 in 8 instars and 9 in 9 instars.

From these results it is shown that the males usually mature with one molt less than the females. Table IV gives the length in days of the nymphal stadia. It is seen from this table that the average length of the stadia decreases from 16.6 days in the first stadium, through the second instar to only 9.6 days in the third stadium, remains about the same through the fourth, and then increases steadily to 18.7 days in the ninth. This shortening of the length of the stadia after the first instar and its subsequent increase is probably the normal pattern of development. Any variations from such a curve are likely to be the result of fluctuations in food supplied or of unusual conditions of temperature or humidity.

The total time required for development of the nymphs is given in Table V. These figures are averages for the groups of nymphs under consideration.

It will be noted in Table V that the average developmental period of the nymphs for the combined 1932 and 1933 generations was 114.2 days. This may be considered as the average developmental period of

Stagmomantis limbata. The average for the 1932 generation was 114.7 days and for 1933, 113.4 days. The minimum period required for development of a nymph was that of a female that in 1933 matured in 89 days; the maximum, a male that in 1933 required 138 days.

A point that should be noted is that although in 1932 the females required one more molt than the males, with an average developmental period 7 days longer; in 1933 the females matured in 10 days' less time, although still requiring one more molt than the males.

TABLE V

SUMMARY SHOWING THE AVERAGE NYMPHAL DEVELOPMENTAL PERIOD OF THE 1932–1933 GENERATIONS OF *Stagmomantis limbata*, UVALDE, TEXAS

	Number of Molts Required for Maturity	Sex of Nymphs		Time Required for Development of Group
		Males	Females	
				Days
1932 generation	7	2	.....	102.5
	8	12	5	109.1
	9	3	15	121.3
1933 generation	8	9	2	111.8
	9	3	9	114.8
Total 1932 and 1933	7–9	29	31	114.2
Males 1932	7–9	17	.....	110.9
Females 1932	8–9	.....	20	117.9
Males 1933	8–9	12	.....	118.3
Females 1933	8–9	.....	11	108.0
Total males 1932 and 1933	7–9	29	.....	113.9
Total females 1932 and 1933	8–9	.....	31	114.4
7-instar nymphs 1932	7	2	.....	102.5
8-instar nymphs 1932–1933	8	21	7	110.1
9-instar nymphs 1932–1933	9	6	24	118.7

LONGEVITY

The data concerning the longevity of these specimens of *Stagmomantis limbata* were necessarily affected by the fact that the insects were reared under more or less artificial conditions. Protected as the mantids were, they had every opportunity to live for the maximum period. In 1933, 2 males lived for an average of 50 days and 5 females for an average of 150 days. In 1932, 6 males lived for an average of 78 days and 8 females for an average of 116 days. Under laboratory conditions the females lived about twice as long as the males. The extreme maximum periods of adult life were: For the males, 116 days for one individual in 1932, and for the females, 175 days for one individual in 1933.

PARASITES OF STAGMOMANTIS LIMBATA

No parasites of *Stagmomantis limbata* were taken at Uvalde, as egg masses were not exposed there, but parasites were reared from the original egg masses received from Superior, Ariz. The date of parasitization was unknown, and some of the parasites had already emerged. From four egg masses the following parasites emerged in 1932: No. 1, March 18—April 2, 7 *Eupelmus brevicauda* Cwfd.; No. 2, March 23—April 2, 22 *Podagrion mantis* Ashm., 5 *P. crassiclava* Gahan; No. 3, April 21, 5 *P. mantis;* No. 4, May 2, 5 *P. mantis.*

FEEDING HABITS

The exact food consumed by a mantid in nature is problematical, as the food chosen is more or less that which wanders in reach of the insect. However, the nature of the vegetation that the species of mantid frequents and whether it ranges upon the ground or elsewhere determine to some extent its diet. *Stagmomantis limbata,* like *S. carolina,* is found in low brush, on blooming plants, and near habitations. This means that many flies are eaten. Particularly are blowflies that come to flowers to feed captured by mantids. Mantids eat only living insects, which they seize and hold with their forelegs. In the genus *Stagmomantis* it is customary for the insect to sit motionless until the luckless prey wanders within reach. However, mantids are frequently observed to move upon their prey.

The specimens of *Stagmomantis limbata* reared in the insectary were fed entirely upon flies. Roughly, they were given daily the following food: First and second instars, 2 *Drosophila* sp.; third instar, 4 *Drosophila* sp.; fourth and fifth instars, 2 horn flies, *Haematobia irritans* L.; sixth and seventh instars, 2 house flies, *Musca domestica* L.; eighth instar, 3 house flies; ninth, 4 house flies; adults, 4 or more house flies and blowflies. The blowflies used were *Cochliomyia macellaria* Fab. and *Sarcophaga* spp.

A female *Stagmomantis limbata* consumed on an average, therefore, from hatching to death, 96 *Drosophila* sp., 48 horn flies, 179 house flies, and 464 blowflies, or a total of 787 insects.

CROSSING STAGMOMANTIS LIMBATA WITH S. CAROLINA

The two species *Stagmomantis carolina* and *S. limbata,* although occurring side by side in the Southwest, have never been known to cross and produce a hybrid. The two species, though separated on quite evident structural characters, are in general appearance similar.

In September of 1932, reared unmated individuals were used in an attempt to cross the two species. Four matings were made: One male of *Stagmomantis limbata* was placed with a female of *S. carolina,* and three females of *limbata* were paired with males of the other species. Normal copulation occurred, and the males and females seemed perfectly suited. The *carolina* female produced four egg masses from October 2 to December 4, all of which were infertile. Of the three *limbata* females, two produced three egg masses each from October 10 to Decem-

ber 17, all being infertile. The third female laid four egg masses on September 17, October 9, November 3, and December 7, respectively, of which the last two were infertile. The first two hatched, one on April 1 to 4 with 9 nymphs, average incubation period 198 days, the second on April 17 to 18 with 13 nymphs, average incubation period 190.4 days. These nymphs appeared to be abnormal. Many of them were deformed, some unable to move about, none of them responded to feeding, and all died within a few days.

In September, 1933, experiments in crossing the two species were repeated with reared, unmated specimens. A male of *Stagmomantis limbata* was mated to a female of *S. carolina* that produced 6 egg masses from September 17 to December 18, all being infertile. Two *limbata* females were mated on September 10 to two males of *carolina*.

The first female laid 7 egg masses from September 11 to December 27, from four of which nymphs hatched, as follows: (1) April 4–6, 7 nymphs, average incubation period 189 days; (2) April 4–24, 15 nymphs, average incubation period 180 days; (3) April 6–13, 21 nymphs, average incubation period 169 days; (4) April 16–19, 16 nymphs, average incubation period 153 days.

The second female laid 6 egg masses from September 17 to December 27, three of which produced nymphs as follows: (1) March 31–April 14, 17 nymphs, average incubation period 186 days; (2) April 4–30, 28 nymphs, average incubation period 174 days; (3) April 13–24, 32 nymphs average incubation period 163 days.

A summary of the egg masses and nymphs thus produced in 1933 is as follows: Total nymphs 136, average nymphs per egg mass 19, average nymphs produced by female 68, average fertile egg masses per female 3.5, average incubation period 173 days.

The nymphs hatched in 1933 were for the most part like those of the preceding year. Many were deformed, and most of them had difficulty in emerging from the egg mass; some few, however, appeared normal. It is regretted that an attempt could not be made to rear these few specimens, but the work was necessarily discontinued at this point. The suggestion is made that some interested worker make this cross again and attempt to rear the offspring.

REGENERATION OF LOST LIMBS

The loss of parts of limbs and their regeneration occurred very frequently during the rearing of *Stagmomantis limbata*. If the loss of a portion of the appendage occurs early in the life history of the nymph, in about the third instar or previous thereto, a complete new limb may be formed. If it occurs in a later instar, however, sufficient molts do not remain to regenerate the limb to full size. The change in the limb occurs at the time of the molt, and each succeeding molt makes it more nearly perfect. The following records taken in 1932 illustrate the points mentioned. It is regretted that a review of literature on regeneration of lost limbs cannot be presented at this time.

On August 15, during the eighth molt, a female nymph lost the tibia and tarsus of the right rear leg. On August 30 the ninth and final molt

occurred, leaving the insect with the two lost segments regenerated with segments clearly visible but only about one-seventh of their normal size.

On May 28, during the third molt, a male nymph lost all but the coxa of the left middle leg. Each successive molt increased the length of the regenerating segments. On July 17 following the seventh molt it was scarcely noticeable that the leg was shorter. Following the eighth and final molt on August 7 the new leg appeared perfect, but measurement showed it to be 28 mm. long while the opposite paired leg was 29 mm.

A male nymph lost two limbs. On May 16, during the first molt, the right middle leg was broken off, only the coxa remaining. After the second molt on May 27 the segments were reformed but small in size. Following the seventh molt, on July 24, the limb was apparently normal, and a careful check at the ninth molt, on August 21, showed no difference from the opposite paired leg. During the second molt, May 27, the tarsus and half the tibia of the right rear leg were lost; following the fourth molt, June 16, the leg was one-half normal size. After the ninth and final molt on August 21 no difference could be found between the regenerated and the paired opposite leg.

SUMMARY

The bordered mantid, *Stagmomantis limbata* Hahn, is found in Mexico, Arizona, New Mexico, and Texas. In 1932 a number of egg masses were collected at Superior, Ariz., and sent to Uvalde, Tex., where a strain of mantids secured from them was continued until 1934. A single generation occurred each year.

The egg cases which were collected in nature were 19 mm. in length and produced an average of 65 nymphs per egg mass with a maximum of 131. In Texas deposition of eggs began in August, and hatching began about March 1. The average incubation period was from 142 to 209 days. Single females produced from 3 to 6 egg masses with an average of 179 nymphs per female and a maximum of 326.

The nymphs molted 7 to 9 times before reaching maturity; most of the males required 8 molts and the females 9. The average number of days required for a nymph to mature was 114.

Adult males lived as long as 116 days and females 175 days. Females mated as early as 5 days after maturity and produced fertile eggs 15 days later.

The parasites *Eupelmus brevicauda* Cwfd., *Podagrion mantis* Ashm., and *P. crassiclava* Gahan were reared from the egg masses collected in Arizona.

The nymphs were fed *Drosophila* sp., *Haematobia irritans* L. and *Musca domestica* L. The adults were given *Cochliomyia macellaria* Fab., *M. domestica*, and *Sarcophaga* spp.

In 1932 and 1933 an attempt was made to cross the two species *Stagmomantis limbata* and *S. carolina*. Seven matings were made, three of which produced fertile eggs. In 1932 two egg masses averaged 11 nymphs, and in 1933, 7 egg masses averaged 19 nymphs per egg mass. Apparently all the nymphs of the 1932 matings were abnormal, many were deformed and incapable of feeding, and all died before reaching maturity. Some of the nymphs in 1933, however, appeared normal, but were not reared to maturity.

Portions of lost limbs were regenerated by the mantids. If the appendage was lost before the third instar, it was regenerated perfectly in form and size. If the loss occurred in a later instar the newly formed leg was complete as to segments but dwarfed in size.

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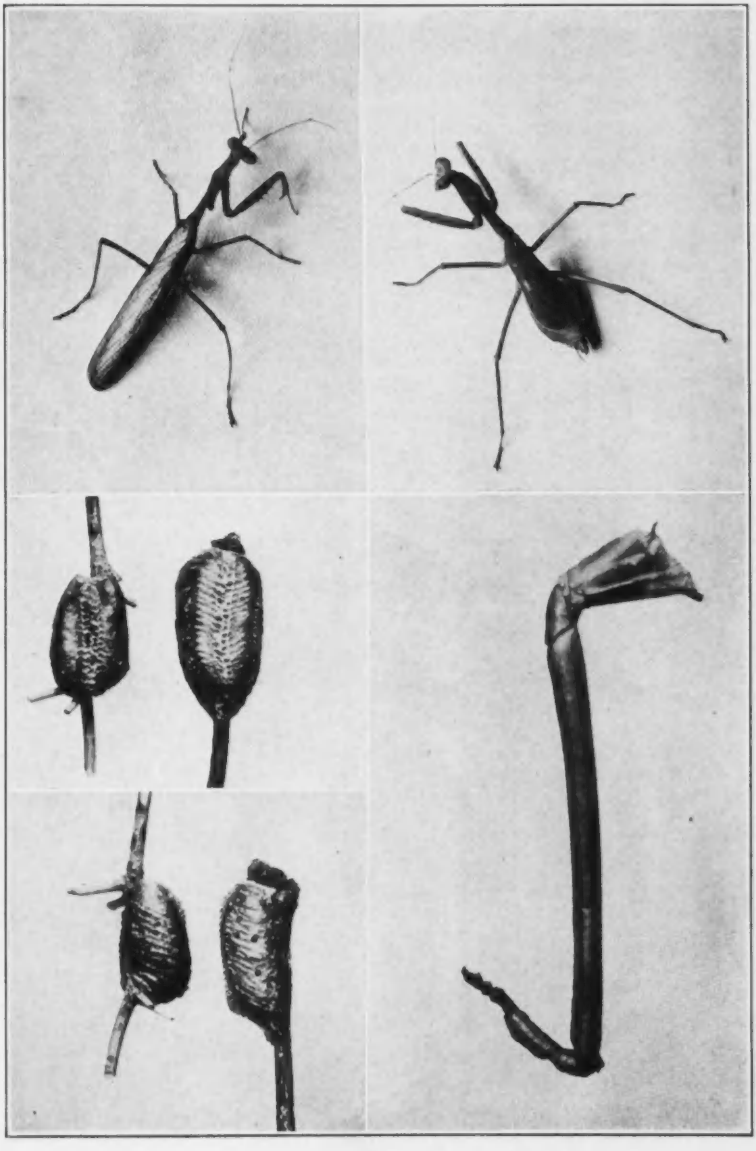
EXPLANATION OF PLATE

Plate I

Stagmomantis limbata Hahn.

Upper left, adult male, ¾ natural size; upper right, adult female, ¾ natural size; center left, egg cases, dorsal view, slightly enlarged; lower left, egg cases, side view, showing exit holes of parasites, slightly enlarged; lower right, leg of adult showing regeneration of tibia and tarsus lost in last nymphal instar, greatly enlarged.



BIOLOGY OF THE MINOR MANTID, LITANEUTRIA MINOR SCUDDER (ORTHOPTERA, MANTIDAE)

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At the very edge of the Rio Grande Plain where rough country marks the sudden ascent to the Edwards Plateau, Uvalde, Tex., lies just below the Balcones Escarpment. Here two geographic divisions of Texas merge, and a diversity of animal and insect life is represented. *Litaneutria minor* Scudder, a small mantid common in the dry West, is sometimes encountered here frequenting low rocky ridges sparsely covered with bunch grass. Less often it is found in low flats where mesquite grass predominates.

These mantids are seldom seen by the causal observer, for their color is such that they are almost invisible, and usually they must be detected by their movement, but a little patient searching usually yields a number of specimens. The insects are not often found on vegetation, as they prefer to run about on the ground and to seek their prey among rocks and short grass stems.

From 1928 to 1934 many records were made of the habits and distribution of this species, and during the summer of 1933 rather complete notes were taken on its life history.

Litaneutria minor was described in the genus *Stagmatoptera* by Scudder in 1871,[2] and was transferred to the genus *Litaneutria* by him in 1896.[3]

DISTRIBUTION

The range of *Litaneutria minor* in North America indicates an adaptation to the dry areas of the West, where it thrives on soil bearing little vegetation. The mantid is found in British Columbia, Montana, Idaho, Wyoming, Nevada, Utah, Colorado, South Dakota, Kansas, Nebraska, Oklahoma, Texas, New Mexico, Arizona, California, and Mexico.

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[1]The author is indebted to the late A. N. Caudell for the determination of material, to Ralph Connor for assistance in rearing specimens in the laboratory, and to Miss Claudelle Lewis for preparation of the drawings.

[2]Scudder, S. H. Notes on the Orthoptera collected by Dr. F. V. Hayden in Nebraska. Final Report of the U. S. Geological Survey of Nebraska, pp. 249–261, 1872.

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EGG CASE

The eggs of *Litaneutria minor* are deposited by the female in a mass, enclosed in a soft spongy substance which hardens to form a case around the eggs. The shape at the base, when the egg mass is cemented to a flat surface, is more or less rectangular with rounded corners. The sloping sides of the elongated mass meet to form a ridge at the top somewhat shorter than the long axis of the base. This ridge extends at one end to form a point or tip. The measurements of 25 egg cases were as follows: Average length 7.2 mm., maximum 11.0 mm., minimum 5.0 mm.; average width at base 4.6 mm., maximum 6.5 mm., minimum 4.0 mm.; average height 4.1 mm., maximum 5.0 mm., minimum 3.3 mm. Near the base the color is light brown, darkening in some specimens to a dark brown at the ridge. The sides are usually coated to some extent with a shining substance that has the appearance of foam. The surfaces of the sides have a ribbed appearance due to the way the mass is deposited in folds. These ribs run from the base to the apex, inclining slightly.

NYMPHS

(Plate I)

First Instar.—Width of head capsule 1 mm., greatest width of pronotum 0.65 mm., length of body including head 4.2 mm., length of pronotum 1.05 mm., length of cephalic femur 1.13 mm.

Vertex of head slightly convex, outer portions of head and eyes extending above (0.15 mm.) and outward to point, giving deep concavity to entire head line.

Body color pale tan with small flecks of dark gray to brown, and with small brownish markings on median dorsal line of thoracic and abdominal segments; head tan with brownish markings, eyes brown flecked with white spots, antennae and mouth appendages banded alternately with gray and dark brown; legs grayish spotted with dark brown, bands on tibia at junction with tarsus and at tarsal joints dark brown, terminal spine of fore tibia reddish brown, markings on coxae of second and third pairs of legs dark brown.

Second Instar.—Width of head capsule 1.23 mm., greatest width of pronotum 0.81 mm., length of body including head 6.20 mm., length of pronotum 1.30 mm., length of cephalic femur 1.40 mm.

Dorsal headline laterally less abruptly concave.

Body color slightly darker and more uniformly tan than in first instar, markings on body less distinct except on median dorsal ridge; bandings on legs slightly less distinct.

Third Instar.—Width of head capsule 1.47 mm., greatest width of pronotum 0.94 mm., length of body including head 7.62 mm., length of pronotum 1.76 mm., length of cephalic femur 1.79 mm.

Body color a more even tan than in first and second instars, markings the same but not so distinct; bandings of antennae and mouth parts less marked.

Sex distinguishable by wing scars extending to point apically in male; female with ventral cleft in sixth abdominal segment evident.

Fourth Instar.—Width of head capsule 1.80 mm., greatest width of pronotum 1 mm., length of body including head 10.16 mm., length of pronotum 2.30 mm., length of cephalic femur 2 mm.

Headline less concave laterally.

Body color same as in previous instars except for more even distribution of brown markings over the body and less distinctness of markings and bandings.

Wing scars showing marked development.

Fifth Instar.—Width of head capsule 2.20 mm., greatest width of pronotum 1.50 mm., length of body including head 14.70 mm., length of pronotum 3.15 mm., length of cephalic femur 3.10 mm.

Headline laterally much flattened.

Body color same as in previous instar; eyes marked more strongly with brown toward forward dorsal point.

Wing scars more distinctly developed.

Sixth Instar.—Width of head capsule 2.72 mm., greatest width of pronotum 1.80 mm., length of body including head 19 mm., length of pronotum 4 mm., length of cephalic femur 3.60 mm.

Body color light tan in some specimens to darker tan in others, brown specks generally distributed over body and legs but small and indistinct except on forelegs, bucca, and rim or margin of pronotum; eyes sometimes splashed with darker color; forelegs with brown to blackish spots inside femur, spines of femur and tibia reddish brown darkening near tip, coxae of second and third pairs of legs grayish, bands on legs reduced to dark shadings, legs in some specimens with greenish cast, particularly on tibia and tarsus.

Males with hind wing pads extending to anterior dorsal border of second abdominal segment and to ventral portion of first abdominal segment; strongly pointed apically as compared with female, in which the posterior margin is only slightly extended at tips; venation of folded wing apparent.

Male with 8 abdominal segments visible ventrally; female with 6.

Seventh Instar.—Width of head capsule 3.08 mm., greatest width of pronotum 1.94 mm., length of body including head 22 mm., length of pronotum 4.92 mm., length of cephalic femur 4.29 mm.

Body color buff to tan with brown markings, with distinct brown line made up of small spots down median dorsal line of thorax and abdomen, thorax with markings on each side of mid dorsal line and running approximately parallel to it; greenish cast to legs and mouth parts, antennae tan with greenish cast.

Wing pads of male extending posteriorly nearly to middle of second abdominal segment.

Femur of forelegs spined as follows: Outer ventral margin with 5 spines, the apical one somewhat smaller than the others; inner ventral margin with about a dozen spines, usually 12 to 14, two of the spines near the base of the row larger than the others; between these and at the base of the ventro-marginal rows of spines, on the medio-ventral line, three large discal spines, the middle one the largest. Large terminal apical spur of the fore tibia fitting, when the tibia is folded against the femur, into a well-depressed groove on the inner ventral surface of the

latter. Fore tibia bearing several, about 7 to 9, ventral spines on the outer margin and the inner ventral margin bearing a similar row of teeth averaging two more in number than those of the opposite row, not counting the very large inner-apical spur.

ADULT

(Plate II)

Color.—Body pale tan, mottled with yellowish brown to grayish brown, markings deepest on dorsal median line of thorax and abdomen, sometimes appearing as a stripe; prothorax marked around margin and on median line with dark brown raised points, presenting a roughened appearance in female; tegmina varying from pale tan to darker brown, wings of male lightly fuliginous with sub-basal fuscous spot; head brown flecked with darker brown, eyes dark brown flecked with grayish white, antennae tan; legs lighter than body, speckled and mottled, especially on fore femora, segments of legs darkening apically, giving the appearance of rings on tibia and tarsal segments, spines darkening to reddish brown on tips. Female grayer and more mottled than male.

Male.—Length of body including head 29.8 mm., length of pronotum 6.0 mm., length of tegmina 20.2 mm. (long, reaching nearly to tip of abdomen), length of antennae 17.5 mm., length of cephalic femur 5.1 mm., greatest width of head 3.8 mm., greatest width of pronotum 2.3 mm.

Female.—Length of body including head 30.2 mm., length of pronotum 7.0 mm., length of antennae 8.0 mm., length of tegmina 7.4 mm. (short, abortive), length of cephalic femur 6.1 mm., greatest width of head 4.2 mm., greatest width of pronotum 3.1 mm.

All measurements of both sexes are averages based on numerous specimens.

BIOLOGY

All material was reared in a screened insectary where temperatures and surroundings were as nearly natural as possible. Each egg case was placed separately in a corked glass vial. Immediately after hatching, the nymphs were separated and each one was placed in a glass vial. This was necessary because of their cannibalistic habits. After a nymph reached the third instar it was placed in a half-pint glass jar with lid of 60-mesh brass strainer cloth. A small stick furnished a place to climb and later served for attachment of egg masses.

No water was furnished the mantids, but living insects were fed to them daily. It is probable that the regularity and abundance of the food given them made them develop faster than if they had been in the field.

LIFE CYCLE

The normal cycle for *Litaneutria minor* as shown by specimens in the laboratory is as follows: Egg masses, which are produced in the fall, pass through the winter; the nymphs hatching in the spring mature by the following autumn, and produce more eggs. Although it appears

that *L. minor* has only one generation a year, there is some evidence to indicate that under certain conditions two generations may be produced.

Adult females that produced eggs as early as June 11 were taken in the field. For these females to have matured by June 11 would have required that they mature in a minimum period which would have placed their date of hatching in the middle of March (not allowing for a preoviposition period). No eggs under observation have ever hatched before April 20. It appears, therefore, that some adult females or nymphs must overwinter as such. This would permit two generations or a partial second generation. It may be that in such a climate as that at Uvalde, Tex., development and growth of nymphs continue during the winter.

PRODUCTION OF EGG CASES

The specimens reared in the insectary began depositing eggs as early as September 6, and unfertilized females have even deposited eggs by August 19. Oviposition has continued as late as December 13. Eggs laid on this date, however, did not hatch. Fertile eggs were laid as late as October 31. Specimens collected in the field have produced fertile eggs as early as June 11 and as late as November 21.

A female in captivity deposited 10 egg cases, 8 of which contained fertile eggs. A study of all the laying females shows that an egg case was produced on an average every 10 days. The shortest period between ovipositions was 5 days.

Frequently a fertile female will deposit one or two infertile egg masses. She will become productive again, however, for only one fertilization by the male is required in a lifetime. The period from copulation to the production of eggs may be as short as 2 days provided the female has reached sexual maturity.

Unmated females began producing infertile egg masses from 25 to 30 days after the final molt. Females mated before 25 to 30 days after maturity were stimulated to lay egg masses sooner, but these were infertile, and not until 30 to 35 days after maturity were fertile eggs produced.

Copulation requires from 3 to 4 hours in these mantids. Following copulation the female may capture and eat the male, though often he escapes.

It is probable that females of *Litaneutria minor* usually deposit their egg cases on stems of plants and fairly close to the ground. The only egg mass seen in nature by the writer was on a small bush of huajillo, *Pithecolobium brevifolium*, about 3 feet out from the base of the plant and about 1 foot above the ground. It was attached to the under side of a stem one-eighth inch in diameter.

NUMBER OF NYMPHS PER EGG CASE

During the years 1932 to 1934, 27 egg cases produced 434 nymphs, an average of 16 nymphs per egg case. A maximum of 34 nymphs was secured from one egg case. Two females produced 102 nymphs each.

DURATION OF EGG STAGE

Eggs in the insectary hatched under two sets of conditions. Some overwintered and hatched in the spring while others hatched the same summer in which the egg masses were laid.

In 1933, 172 eggs hatched on an average of 30 days after oviposition. These eggs were deposited between June 11 and August 4 and hatched between July 7 and September 30. The minimum incubation period was 22 days and the maximum 111 days.

Eggs laid between October 18 and November 21, 1932, produced 110 nymphs from May 2 to May 13, 1933, in an average of 184 days, the minimum incubation period being 168 days and the maximum 202 days.

Eggs laid between September 6 and October 31, 1933, produced 152 nymphs from April 24 to May 18, 1934, in an average of 205 days, the minimum incubation period being 175 days and the maximum 248 days.

TABLE I. WEATHER RECORDS SHOWING MEAN TEMPERATURE, MEAN HUMIDITY, AND PRECIPITATION, UVALDE, TEXAS, 1932, 1933, AND 1934

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Mean Temperatures (°F.)													
1932..	54.9	61.5	58.8	71.0	75.9	84.4	82.4	83.8	76.1	67.3	55.5	50.1	68.50
1933..	57.1	53.8	65.0	70.2	79.7	80.7	86.3	85.0	83.8	75.9	64.2	60.1	71.82
1934..	55.0	56.5	60.5	72.6	77.4	85.7	85.6	81.8	81.2	75.9	66.2	55.0	71.12
Mean Humidity (Percent)													
1932..	65.7	70.0	57.1	59.7	66.1	63.0	67.2	66.5	72.6	65.8	59.7	73.6	65.58
1933..	66.6	63.8	62.1	54.3	63.7	58.6	58.9	62.2	63.4	60.7	61.4	58.5	61.18
Precipitation (Inches)													
													Total
1932..	0.6	1.6	1.4	1.7	2.0	1.0	20.5	3.5	10.8	0.2	0.8	1.2	45.30
1933..	2.7	1.7	.2	.7	2.8	.8	1.3	1.4	1.1	1.3	.3	.4	14.70
1934..	2.9	.2	.9	1.3	1.9	.2	3.6	.4	1.3	.4	.5	2.5	16.10

TEMPERATURES AND MOISTURE

During 1933 the nymphs of *Litaneutria minor* were reared when the average mean temperature for the year was approximately 1.5 Fahrenheit degrees above normal, the mean relative humidity 1 percent below normal, and the mean rainfall 9 inches below normal. In Table I are listed the mean temperature and precipitation for Uvalde for 1932 to 1934, inclusive, and the humidity for 1932 and 1933. Reference should be made to these records in studying the hatching, development of nymphs, etc.

LENGTH OF NYMPHAL STADIA

The nymphal mantids were examined daily, and as soon as a molt occurred the cast skin was removed and the date of the molt recorded. Beginning May 2, 1933, 76 newly hatched mantids were placed separately in glass vials. Of these, 17 died before the first molt, 39 others died before reaching maturity, and 20 (26 percent) matured. Table II shows the average number of days required for each stadium as well as the total days for all stadia.

TABLE II. LENGTH OF NYMPHAL STADIA IN REARED INDIVIDUALS OF LITANEUTRIA MINOR, UVALDE, TEXAS, 1933

Number of Molts to Complete Development	Sex		Average Number of Days in each Stadium								Total
	Male	Female	I	II	III	IV	V	VI	VII	VIII	
6	2	0	11.0	14.0	8.5	12.5	12.5	14.0	.....	.....	72.5
7	5	7	10.8	13.0	10.3	13.3	11.8	14.0	15.9	.....	89.1
8	1	5	15.3	13.7	12.8	12.3	9.5	14.0	12.0	16.2	105.8
Total or Average	8	12	12.2	13.3	10.9	12.9	11.2	14.0	14.6	16.2	92.5
Average days, including 39 nymphs that died before maturity.....			12.4	14.0	12.0	12.2	10.8	13.4	14.5	16.2	

The average length in days of the stadia of the nymphs that died before reaching maturity was as follows:

Stadium	Number of Nymphs	Average Days in Stadium
I	39	12.6
II	33	14.5
III	27	12.7
IV	22	11.6
V	20	10.4
VI	7	11.6
VII	1	13.0

The last line of Table II shows these figures averaged with those of the reared individuals.

There appears to be no progressive increase or decrease in the length of the stadia. However, generally speaking, the latter stadia were somewhat longer than the first. Other variations which are slight were probably due to more favorable conditions or excess of food. The minimum period spent in any stadium was that of a male which completed the first in 7 days; the maximum, a female that required 21 days in the sixth stadium. There appears to be no difference in the time required by males or females to complete a stadium. However, since the males undergo fewer molts they generally attain the adult stage first. Two males required only six molts to reach maturity.

LONGEVITY

The figures secured on the length of life of *Litaneutria minor* must be considered with regard to the fact that, owing to living a protected life, their longevity may have been above the normal. On the other hand, under outside, natural conditions, they might have lived even longer. While the data at hand are scarce, owing to the difficulty of rearing the adults, the results, particularly the maximum figures, are interesting.

Five reared males lived an average of 25 days, with a maximum of 47 days for one individual. Nine females lived an average of 74 days, with one individual living 156 days and another 129 days.

FEEDING HABITS

Because *Litaneutria minor* is a frequenter of the ground, its food is more likely to be made up of insects of this same environment. In nature it probably feeds on immature grasshoppers, small beetles, flies, aphids, and other living insects. As this mantid is very active and runs rapidly about, it probably is more aggressive in pursuing its prey than larger mantids such as those of the genus *Stagmomantis*. While few notes could be taken of the natural feeding habits of this insect, numerous records were taken in the laboratory. The adults fed readily on any of the medium-sized blowflies and were usually given *Cochliomyia macellaria* Fab., *Lucilia* sp., and *Musca domestica* L. In rearing the mantids the following were furnished: In the first instar, 1 aphid daily; second instar, 2 aphids daily; third instar, 1 *Drosophila* sp. daily; fourth instar, 2 *Drosophila* sp. daily; fifth instar, 3 *Drosophila* sp. daily; sixth instar, 1 housefly, *M. domestica*, daily; seventh instar, 2 houseflies daily; eighth instar, 1 blowfly each day.

The average female of *Litaneutria minor* could consume the following food during the period from hatching of the egg until death: 40 aphids, 70 *Drosophila*, 43 houseflies, and 90 blowflies, or a total of 243 insects.

SUMMARY

The minor mantid, *Litaneutria minor* Scudder, is a small species found in the western part of the United States and Mexico. At Uvalde, Tex., records were made on the insect from 1928 to 1934.

The mantid normally has a single generation each year but at Uvalde, Tex., during years with warm winters, a partial second generation occurs.

The female may lay as many as 10 egg masses (7 mm. in length); these are deposited on stems of low-growing shrubs. Females mated and produced fertile eggs about 30 days after reaching maturity. Egg masses produced an average of 16 nymphs each. The average incubation period for overwintering

eggs was 184 days in 1932–33 and 205 days in 1933–34. Eggs deposited early in the summer hatched in 30 days.

In 1933, from an attempt to rear 76 nymphs, 20 reached maturity. Six molts each were required for two males, 7 molts were required for 5 males and 7 females, and 8 molts for 1 male and 5 females. As a rule the female required one more molt than the male. The nymphs, on the average, reached maturity in 93 days. Adult males lived as long as 47 days and females for 156 days.

The nymphs were fed aphids, *Drosophila*, and *Musca domestica* L. The adults were given *Cochliomyia macellaria* Fab. and other blowflies. In nature the mantids probably feed on flies, beetles, and other insects that frequent the ground.

EXPLANATION OF PLATES

PLATE I

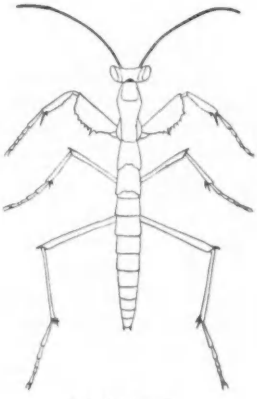
Litaneutria minor Scudd. Nymphal stages. (× 2½).

PLATE II

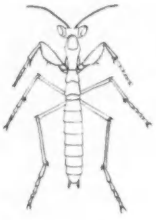
Litaneutria minor Scudd. Left, adult male (× 4); right, adult female (× 4).

1st instar

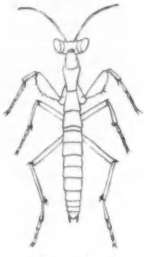
2nd instar



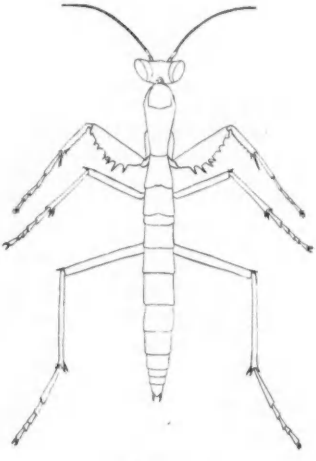
5th instar ♂



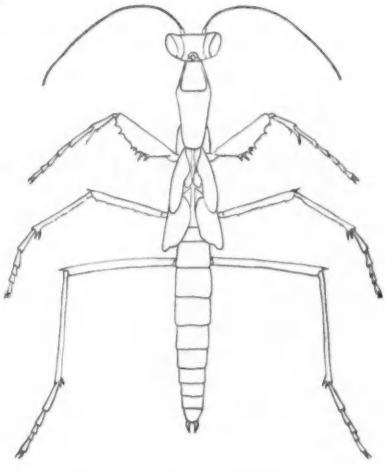
3rd instar ♂



4th instar ♀

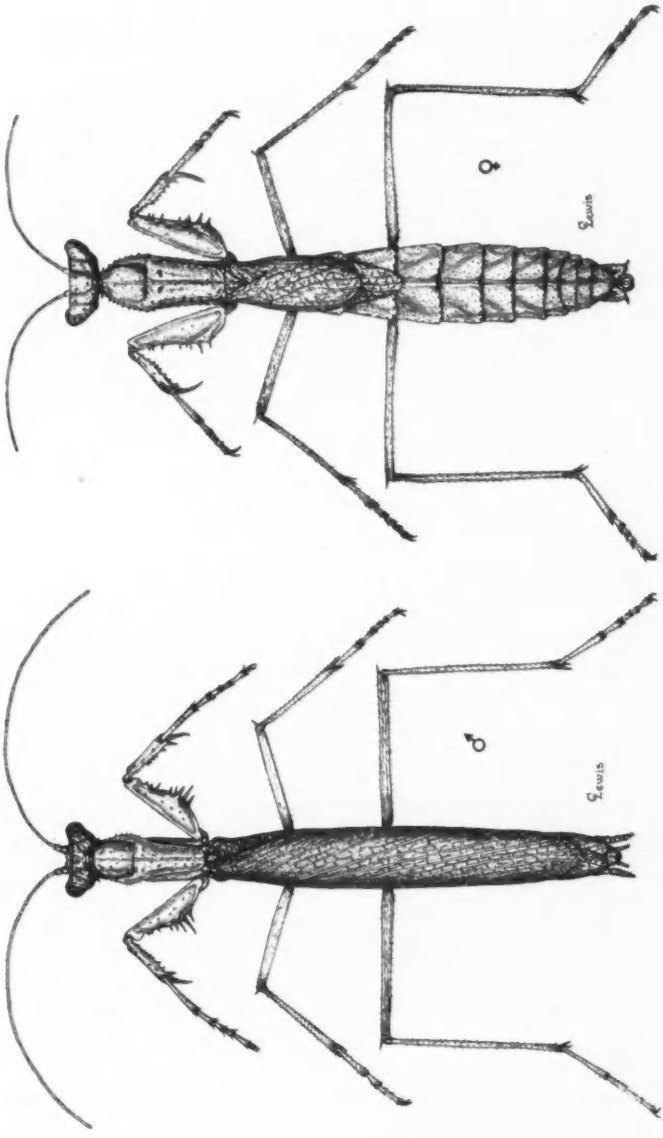


6th instar ♀



7th instar ♂ just before moult.

Litaneutria minor Scudd.
Nymphal stages.
X 2½.



Litaneutria minor Scudd.
4 X.

VERGLEICHENDE ENTWICKLUNGSGESCHICHTE DER TIERE (of KORSCHELT and HEIDER), revised by E. KORSCHELT. Volume I, pp. 1–536, figs 1–560; Volume II, pp. 537–1314, figs. 561–1312. 1936. Published by GUSTAV FISCHER in Jena. Price, unbound, RM 52 ($21.32), bound, RM 56 ($23.00).

This is a complete revision of the four volume work of the same title which appeared in 1890–93 and 1902–10. Compared with the widely used English translation of that work the format of this edition is much better with its larger pages (4.75 x 7.75 inches) which easily carry the larger illustrations necessary to show the details of embryological development.

The first 136 pages are devoted to general problems, the sex cells, maturation, fertilization, cleavage and the germ layers. Following this are thirty-nine chapters each dealing with one or two divisions of the animal kingdom beginning with the sponges and ending with a chapter briefly reviewing vertebrate embryology.

For nearly fifty years "Korschelt and Heider" has been the general reference work on the comparative embryology of animals. Many of its sections have been the general reference works on particular groups. This is especially true of the section on insects. Until very recently no other as comprehensive review of insect embryology existed in any language. In this field the work again assumes command in the one hundred and two pages and one hundred illustrations devoted to this subject. However, it is a large subject because of the many divergent types of development in the insects. Even in the present beginnings of this branch of entomology a moderately good working library on the embryology of insects occupies fifteen to twenty linear feet of shelf space which when boiled down in a general one hundred page review of the subject has to omit many critical things. In the present review we find that the Collembola, a large and very aberrant group, are not even listed in the index and we question the propriety of classifying them in the same bracket as the Thysanura and Diplura in the table (p. 813) on metamorphosis. The same table brings unnatural groups together in the subheads under Neometabola and the Holometabola.

Korschelt recognizes the present trend in thought in the field of insect embryology. The better of the late papers on the subject extend the view of embryological development to include the phenomena of metamorphosis. The evolution of the higher insects compels this view. As insects evolve into the holometabola the larva becomes more and more degenerate (embryonic) while embryonic processes normally found within the egg shell (differentiation of sense organs, limbs, etc.) are suppressed within the egg to reappear in development in metamorphosis and there to complete their embryonic and postembryonic development. The picture of the embryology of any holometabolous insect has to include the processes within the egg at one end of development and those in the prepupa and pupa at the other end of development. They are not separated physiologically. The understanding of one makes possible the understanding of the other.

We will close this notice with a plea to that entomologist or zoologist who has the ability and the opportunity in the matter of appreciation of such work by his superiors (President of his institution, Trustees, Legislature, etc.) to write a comprehensive work on the embryology of insects. It is one of the great needs of theoretical entomology. Such a first attempt could bring together the facts already published and a considerable groundwork of theory. However, we are not ready yet to do much with the theoretical aspects of the subject. Too many aberrant types are yet unexplained or even well described. Such a first work should be in several volumes, voluminously illustrated to assemble in usable form the scattered material already available. It should be written with thorough documentation as a help to the future worker and not to the personal glory of the author. It is needed today in every entomological and zoological laboratory in the world.

Entomologically this edition of "Korschelt and Heider" is the best we have on the subject and the same can be said for it in the broader zoological field. It will remain as it has been for over thirty years the most widely used general reference work on comparative embryology. The work is in the superb format and quality of paper, of binding and of illustration found regularly in the publications sponsored by Gustav Fischer in Jena.—C. H. K.

THE BIOLOGY OF OÖENCYRTUS JOHNSONI (HOWARD), AND THE ROLE OF THE EGG SHELL IN THE RESPIRATION OF CERTAIN ENCYRTID LARVAE (HYMENOPTERA)[1]

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In the course of an investigation of the eggs and first instar larvae of several species of California Encyrtidae, the life history of *Oöencyrtus johnsoni* (Howard), an endophagous parasite of the eggs of the harlequin cabbage bug [*Murgantia histrionica* (Hahn)], was briefly examined. Since the biology of no member of the genus has been extensively described and as this species was found to be peculiar in certain of its habits and structures, the observations are herein recorded. The study was by no means exhaustive and many phases of the biology are worthy of a more thorough investigation.

[1]I wish to express my sincerest appreciation to Prof. H. S. Smith for the use of laboratory facilities and for his many helpful suggestions. An observation of S. E. Flanders concerning the possibility of a relationship between the egg shell of *Leptomastix dactylopii* Howard and larval respiration was an incentive to this investigation. For this and his valuable criticism I am indeed grateful.

The appended discussion concerning the role of the egg shell in the respiration of certain encyrtid larvae is in the nature of a progress report.

BIOLOGY OF OOENCYRTUS JOHNSONI

HOSTS OF OOENCYRTUS SPP.

Oöencyrtus johnsoni has been reared from the eggs of a coccinellid (Walker and Anderson, 1933) as well as from those of *Murgantia histrionica*. It is possible that other pentatomids may serve as hosts.

Most of the species of *Oöencyrtus* are parasitic within the eggs of Lepidoptera. Perhaps the best known is *O. kuvanae* (How.) introduced into eastern United States from Japan in 1908 for the control of the gipsy moth, *Porthetria dispar* L. Some members of the genus are enemies of certain Hemiptera. Four species parasitize pentatomid eggs, two parasitize the eggs of certain Coreidae, and one is reported to attack the eggs of a lophopid leaf-hopper, *Pyrilla*. The hosts, however, are not limited to Lepidoptera and Hemiptera. One species is recorded from *Chrysopa* (Neuroptera) eggs in Trinidad. Two species are parasitic on eggs of certain Coleoptera; one attacks *Moneilema*, a Longicorn beetle, and another a flea beetle, *Podontia*.

GEOGRAPHICAL DISTRIBUTION

Oöencyrtus johnsoni has been found only in Maryland (Howard (1898), Virginia (Walker and Anderson 1933), Florida (Drake 1920), and California (Essig 1922). It may also occur at Estancia, New Mexico, but specimens which emerged from eggs sent by J. R. Douglass on August 21, 1925, to J. C. Elmore of the Alhambra California laboratory of the U. S. Bureau of Entomology, have not been positively identified. Since the host, *Murgantia histrionica*, supposedly migrated from Central America and Mexico, it is possible that *O. johnsoni* may have accompanied its host into New Mexico and other favorable regions.

In California the known distribution includes certain coastal localities in the southern part of the state. Essig (1922) obtained specimens from Balboa Beach to San Juan Capistrano. Elmore secured material June 23, 1925 at Costa Mesa, a few miles inland from Balboa Beach. A constant supply was available to the writer during the late summer of 1936 from an area near Costa Mesa. The genus *Oöencyrtus* is nearly world-wide in distribution. Species have been recorded from the temperate and tropical regions of all the continents with the exception of South America.

TAXONOMY

This encyrtid parasite was described by L. O. Howard (1898) as *Encyrtus johnsoni* from two females and one male reared from the eggs of *Murgantia histrionica* (Hahn) by W. G. Johnson at College Station, Maryland. Ashmead (1900) erected the genus *Oöencyrtus* and placed in this group *Encyrtus johnsoni* together with four other species originally described under *Encyrtus*. Mercet (1921) was of the opinion that

Schedius, erected by Howard (1910) for the new species *kuvanae* on gipsy moth, might prove to be a synonym of *Oöencyrtus*. Timberlake (1923) demonstrated the synonomy of the two genera. *Oöencyrtus* now embraces fifty species, most of which are parasites of lepidopterous eggs. In the United States there have been recorded five presumably endemic species. In California one other species occurs in addition to *johnsoni*, namely *californicus* Gir.

The species herein discussed is undoubtedly the same as that described by Howard and recorded by Essig. Essig's specimens were identified by A. B. Gahan.

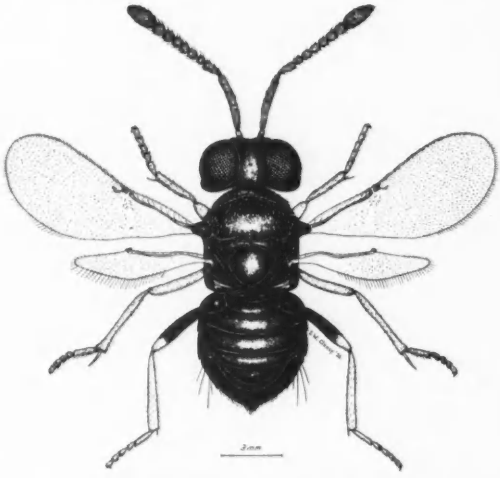

FIG. 1. *Oöencyrtus johnsoni* (Howard). Adult female.

REPRODUCTION

TECHNIQUE IN REARING AND STUDY OF DEVELOPMENT

In order to insure a daily supply of host material, fifty adult *Murgantia histrionica* were placed in a 15°x15°x36° frame cage covered with bleached muslin and provided every third day with wild mustard plants, [*Brassica incana* (L.),] in jars of water. The cage was placed in the laboratory and the egg masses removed daily. These were refrigerated in corked vials at 45° F until needed. Eggs which were held thus for as long as six days were suitable for rearing the parasite.[2]

Oviposition experiments were conducted in 1″x1¼″ cotton plugged shell vials attached horizontally with scotch tape to filing cards (4″x6″), three to a card. This arrangement prevented rolling and disturbing

[2]No effort was made to determine the maximum period of storage. Of 100 eggs refrigerated one month and exposed to the parasites, 2 hatched, 60 were watery or contained undeveloped embryos, and 38 produced parasites.

the parasite, provided a method of ready observation, and permitted the recording of data on the card. Usually two females were confined for nine hours with a single egg mass, since one female will parasitize a maximum of six eggs (approximately half the number in one mass) in that time. The parasitized eggs were retained in the vials for study. In order to separate the eggs for dissection without injuring them, the egg mass was placed in a drop of distilled water to soften the adhesive material.

Dissections were made in Ringer's solution. In order to observe the detail of the tracheal system, the living larvae were examined in the normal salt solution or in Hoyer's solution. Several methods of observation were necessary, none of which was entirely satisfactory. When the normal salt solution was spread in a thin film on a glass slide, some of the tracheae were discernable without a cover-glass. If a cover-glass was used, care was taken not to crush the specimen. Drying of the material was avoided by periodically adding distilled water. Larvae mounted in Hoyer's solution were quite satisfactory if observations were made immediately, since the air in the tracheae was quickly displaced. Glycerine mounts were unsuitable because of shriveling of the specimens. Ovarian eggs were best observed in detail by staining the ovaries five to ten minutes in acid fuchsin in lactophenol[3] and then mounting them in Hoyer's solution.

All rearing experiments were conducted in an insectary room maintained at 75°–80° F with an average temperature of approximately 78° F. The relative humidity varied from 64% to 75% and averaged about 68%.

Adult life was prolonged by refrigeration at 45° F in tightly corked vials and with weekly feedings of dilute honey .

All drawings were made with the aid of a camera-lucida.

MATING

Copulation may occur almost immediately after emergence. The process, although complicated, requires only a few seconds. After coition, the female no longer responds to the sex stimulus and does not copulate again.

OVIPOSITION

Procedure.—The female spends considerable time wandering slowly over the egg mass, continuously testing it with the antennae. The host exhibits a strong attraction for the parasite for the egg mass is seldom left before it has been completely parasitized. When straying does occur, it is ordinarily for short distances and the return is almost inevitable. Because of this behavior, the eggs can be removed from the oviposition vial after a female begins to inspect them and the entire procedure readily observed under a dissecting binocular microscope.

After having completed the examination a position is assumed, usually on the side of the egg facing toward the base. The body is elevated and the abdomen lowered until the tip of the ovipositor touches

[3]Suggested by the preparation outlined by Langeron (1934). It consists of 50 gms. phenol, 50 cc. lactic acid, 50 cc. glycerine, 50 cc. distilled water, and ½ gm. acid fuchsin.

the chorion. The end of the sheathed ovipositor is used to tap a position on the surrounding surface. The sheaths hold the ovipositor at the tip in much the same manner as one grasps a pencil at the end by the thumb and forefinger. By this method the ovipositor is supported for the initial thrusts. Once insertion is begun the sheaths are removed for the remainder of the process as the abdomen returns to the normal position. The ovipositor extends backward at approximately a 75° angle to the long axis of the body. Occasionally when difficulty of some sort is encountered or conditions are unsuitable for oviposition, the sheaths return to "grasp" the ovipositor and support it for additional thrusts.

During the penetration of the chorion there are three motions of the ovipositor. These can be observed with the aid of transmitted light and any debris that accumulates on the ovipositor. There is an up and down motion brought about by the raising and lowering of the body. The action is at first rapid but slackens toward the end of the period. There is also a rotating motion in which usually three-fourths to seven-eighths of a complete turn is made. This also is rapid at first, then slackens, and the distance the ovipositor turns becomes irregular. A third motion is the sliding of the two stylets on one another. There was no appreciable rhythm to this action. During all these motions material accumulates around the puncture, some of which winds around the ovipositor, as do shavings from a drill. Gradually the frequency of the motions is reduced. Then the abdomen is suddenly lowered so that it touches the surface of the host at the point where the ovipositor enters the body. There it pauses for several seconds while the ovipositor continually and rapidly rotates. Partially withdrawing the ovipositor, the debris collected upon it is left upon the egg surface. The process is repeated at least six times. As the ovipositor is gradually withdrawn, it is slowly turned. Occasionally the parasite feeds on any exudations that may be present. This phase preliminary to oviposition usually requires from nine to fourteen minutes and frequently longer.

A quiescent period follows during which the female remains on or near the host from ten to forty-five minutes, or several hours if she is newly emerged. Usually about fifteen minutes is sufficient. She then relocates the puncture by means of the debris on the egg surface. Upon locating this material with the aid of her antennae, a position similar to that assumed at the beginning of the process is taken. By tapping about with the sheathed ovipositor the puncture is found and the ovipositor is reinserted. It is quickly run up and down by rhythmic action of the body and rotated until a large drop of translucent liquid appears. Removing and sheathing the ovipositor she then backs away and rapidly laps up the drop. This procedure is repeated from seven to eleven times, the drops becoming successively smaller. Even though no liquid is observable, she continues her attempt to "pump" additional material from the egg.

After feeding is completed the ovipositor is again reinserted and the body lowered until it touches the chorion. It remains thus for several seconds, while the abdomen pulsates, then rises again. This is repeated three or four times. When the body is lowered for the last time, the larger body of the double-bodied ovarian egg (Fig. 2-A), the

egg proper, is deposited, for when the ovipositor is withdrawn, the end of the neck of the ovarian egg, which is to form part of the protruding stalk, appears at the surface of the host. The stalk seems to be placed in position by the female retaining one of her stylets within the host and partially withdrawing the other so that the neck assumes a position parallel and contiguous to the stylet remaining within the host. With the neck in position the ovipositor slowly makes several three-quarter turns accompanied by a rapid probing motion. The abdomen then pumps convulsively without agitating the ovipositor. At this time the remainder of the egg, the smaller body or bulb of the ovarian egg, may be seen traveling down the ovipositor. As the last portion of the bulb approaches the tip, the neck bows out. Then the collapsed bulb springs free. After sheathing the ovipositor any liquid on or around the protruding stalk is occasionally consumed. This second phase of oviposition usually lasts eleven to thirteen minutes, although it may be much longer because of more time being consumed in feeding.

After one egg is deposited usually a second or in some cases a third egg is immediately deposited through the same aperture (Fig. 5) at times without sheathing the ovipositor. Only the second oviposition phase is repeated and in some observed cases no feeding occurred. If only a single egg is deposited, the procedure is recommenced on another egg.

Since the deposition of an egg requires considerable time, few eggs are laid in the course of a day. Three females were timed to determine the rate of oviposition during a 9-hour period. One female parasitized 4 eggs, with a minimum time between ovipositions of 52 minutes and a maximum of 1 hour and 45 minutes. Another female parasitized 6 eggs with a minimum of 47 minutes and a maximum of 1 hour and 58 minutes between depositions. A third parasitized 5 eggs with a minimum of 55 minutes and a maximum of 2 hours and 30 minutes. In the longer periods most of the time was spent resting or feeding, especially the former. The minimum time of 47 minutes is much longer than for *Oöencyrtus kuvanae* which, according to Crossman (1925), ordinarily requires only 10 to 20 minutes.

Significance of the first phase of oviposition.—During the first phase of oviposition, the parasite may be assumed to be concerned solely with puncturing the chorion of the host. However, the activity together with the subsequent behavior of the female suggest that the process has an additional significance.

The debris which is left around the aperture at the conclusion of the first phase undoubtedly aids the parasite to relocate the opening. If this debris is removed, some difficulty is experienced by the parasite, and in some observed cases the process was recommenced. There were times when the parasite succeeded in locating the aperture, but it is quite possible that all traces of the material were not successfully removed. Memory apparently plays no part, for in many cases when one female was interrupted and removed, another female exposed to the same egg mass would continue the process and oviposit. If several females are removed after they have been permitted to puncture the eggs and only one of them is reintroduced, the egg selected seldom is

the one she herself had punctured. Almost invariably the eggs that have been punctured are sought prior to initiating the preliminary phase on unpunctured eggs, i. e., they will oviposit through a puncture made by another female in preference to making one of their own.

This possible function of the debris may be secondary. The material may surround the mouth of a feeding tube which may be similar to that constructed by certain other hymenopterous parasites, e. g., pteromalids (Fulton 1933). The sculpturing on the chorion of *Murgantia histrionica* eggs is somewhat porous or honeycombed and in order to obtain the liquid from the egg, a tube of some sort may be necessary to prevent the material from seeping laterally. So far as known no feeding tube is present in the Encyrtidae and its existence could not be demonstrated by dissection. It is possible that the material at the aperture is no more than an exudation from the egg or simply "shavings" from the drilling process. However, it may be inferred from the complicated nature of the first phase of oviposition, which is invariably followed by feeding in the second phase, that a tube is formed. Parasites using feeding tubes ordinarily do not extract the material by any ovipositor action but obtain it by applying suction to the aperture of the tube. *O. johnsoni*, however, laps up the fluids and does not appear to apply the mouth at the opening for suction purposes. The presence of the drop seems due invariably to the continual jabbing of the ovipositor, for material will not exude without this action and will often recede within the egg before it can be consumed. This behavior of the liquid suggests that air is "pumped" into the egg to force the material out.

Host eggs that have been subjected to this process seldom hatch. This was demonstrated by incubating punctured eggs. Samples of the same egg mass were retained as checks. Thirty-three eggs were punctured and of these only two hatched. Of the 31 non-punctured eggs, 24 hatched and 7 failed to hatch, 6 of which contained full-formed embryos and one was undeveloped. The contents of the punctured, unhatched eggs were watery, whereas those of unpunctured, unhatched eggs were usually granulated. Whether the failure of punctured eggs to hatch is due to the mechanical effect of the ovipositor or a chemical one produced by the parasite is not known.

Number of eggs per host.—In the laboratory the parasites were observed to deposit from 2 to 3 eggs in a host. One egg was less frequently deposited than 2, and 3 eggs were only slightly more often encountered in dissections than one per host. In instances where more than 3 eggs were found in a host they were deposited by two or more females. One female may oviposit through the same puncture as that made by another female, but their combined eggs number no more than three. If there is only one egg, it will hatch and the larva will mature. All the contents of the host are consumed, yet the adult is not noticeably larger than normal adults, i. e., adults that have matured two to a host. Apparently a single larva engulfs all the host's contents so that it can pupate, then it voids the unused portion in the meconium.

The number of adults maturing in a host may give some indication of the number of eggs deposited. In Table 1 are listed the progeny of three mated and three unmated females together with the number of

host eggs parasitized under laboratory conditions. There was a total of 316 eggs parasitized from which 648 adults were obtained. The average number developing in an egg was 2.05. This would indicate that usually two eggs and sometimes three are deposited in a host. This is also apparently true under field conditions. Three hundred and eighty-four parasites developed in 181 parasitized eggs, or an average of 2.12 parasites per egg. This can be no accurate figure of the number of eggs laid, however, for the extent of superparasitism and the per cent mortality of immature stages in either the laboratory or field material were not determined. Walker and Anderson obtained 35 parasites from 12 eggs, or an average of almost three from one egg.

Oviposition period.—At emergence females contain well-developed ovarian follicles and within 12 hours a few mature eggs are formed. This species is similar to *O. kuvanae* in that oviposition often begins during the first day of adult life. Newly emerged females of *O. johnsoni* lay only a few eggs the first day, usually one or two at the most, and but few more the second day. Thereafter they oviposit readily.

TABLE I. PROGENY AND LONGEVITY OF MATED AND UNMATED FEMALES

Mated or Unmated	No. of Eggs Parasitized	Progeny		Undeposited Eggs	Total	Longevity in Days
		Male	Female			
Mated.....	40	12	66	2	80	22
Mated.....	43	10	79	20	109	21
Mated.....	44	32	62	14	108	20
Unmated....	37	78	.....	16	94	23
Unmated....	37	85	.....	12	97	20
Unmated....	115	224	.....	?	?	116+

The period of oviposition was found to be usually 18 to 23 days in the laboratory. Of five of the six females listed in Table 1 three completed oviposition in 18 days, one in 20 days, and another in 23 days. This is about half the period reported for *kuvanae* which Crossman found to extend over six weeks, seventy per cent of the oviposition taking place in the first three weeks of adult life. In *johnsoni* most of the eggs were deposited within two weeks after emergence.

The sixth female listed in Table 1 deposited eggs for 20 days after emergence, then no more for 32 days. At the end of that time egg laying recommenced and continued until the 98th day. During the 7 succeeding days no eggs were deposited. At the end of that time oviposition continued daily, and at this writing the only indication of its cessation is the reduction of the number of eggs deposited at each exposure to the host. The other females in the experiment probably died prematurely due to excessive summer temperatures. Consequently no accurate data are available concerning the length of the oviposition period.

Stage of development of the host.—*O. johnsoni* will oviposit in host eggs in almost any stage of development. In this respect it is similar to

O. kuvanae, the larva of which "consumes the entire embryo if it is in a new egg in which the host larva has not developed" (Crossman). *O. johnsoni* may experience some difficulty if the host eggs have just been deposited. In two observed instances the parasites ceased "drilling" on the eggs when portions of the contents began to exude. After a few hours the process was resumed and the eggs deposited.

Both *johnsoni* and *kuvanae* will oviposit in eggs in which the embryo is completely developed. In the latter species the larva consumes the entire caterpillar with the exception of the hard chitinized parts and the hair. This, however, is not usually the case in *johnsoni*. Although this species will oviposit in mature embryos, the larvae do not always complete their development. In one instance an egg mass was exposed to the parasite, eclosion occurring in some cases the same day. Four of the twelve eggs were parasitized, and when these were dissected after six days, each contained a nymph which appeared to have completely developed before being killed by a single larva. The parasite's eggs had been deposited within the mature embryos, and the larvae, which were in the fourth instar, were surrounded by the integument of the embryo. In all cases these larvae had definitely begun to decompose, although the developed embryos were not emptied of body fluids.

If the eggs are no less than 24 hours from eclosion, when the incubation period is seven days, the parasite larvae will complete their development. The entire contents of the embryo are consumed, leaving the egg-burster and portions of the integument which are flattened against the inside of the chorion of the host. In no case was more than one pupa found when completely developed embryos had been parasitized.

There is some evidence that host eggs in advanced stages of development are preferred to newly deposited eggs, i. e., when the incubation period of the host is seven days, there is an indication of preference by the parasite for eggs 3, 4, and 5 days old.

EGG

Ovarian egg.—The ovarian egg (Fig. 2 A) is typical of those of most Encyrtidae in that it is composed of a large elliptical body, the egg proper, and a smaller irregular ovoid body, the bulb, which are connected by a narrow stalk, the neck. The measurements of the ovarian egg illustrated were:

Length of bulb	0.158 mm.
Width of bulb	0.064 mm.
Length of stalk	0.3 mm. approximately.
Width of stalk	0.013 mm.
Length of egg	0.18 mm.
Width of egg	0.09 mm.
Total length	0.64 mm. approximately.

The stalk is attached at the end of the egg and slightly to one side so that laterally the egg appears to be more convex on one side, whereas from the dorsal or ventral aspect it is centrally located. The shape of the bulb varies, though the size is fairly constant. The vertex of the bulb is slightly thickened.

On mature ovarian eggs extending from the base of the bulb along the neck and almost the length of the egg is an area which appears

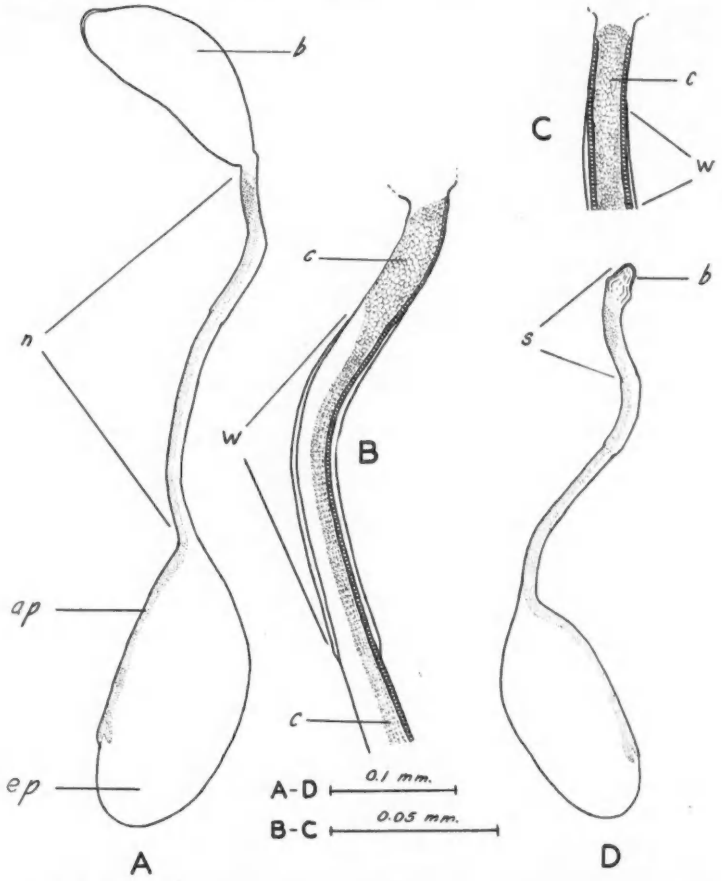

FIG. 2. Egg. A. Lateral view of ovarian egg. The specimen was somewhat compressed. B. Lateral aspect of anterior end of stalk. C. "Ventral" aspect of anterior end of stalk. D. Deposited egg. The specimen was not compressed. ap., "granulated" band; b., bulb; c., "cells" of "granulated" band; ep., egg proper; n., neck; s., portion of stalk protruding from host; w, thickened wall.

coarsely granulated. The morphological detail of this structure is not yet known and at present only its gross appearance may be described.

This "granulated" area covers a portion of the egg in the shape of an elongate band approximately 0.09 mm. wide at its greatest breadth,

and 0.15 mm. long. It appears to be composed of a mosaic of "cells" of various sizes distributed in much the same manner as illustrated (Figure 3, A). This mosaic continues for the length of the stalk. Viewed laterally (Fig. 3, B) the band appears to be composed of a layer of "cells" which cover one-half of the neck, except at its apex, at which

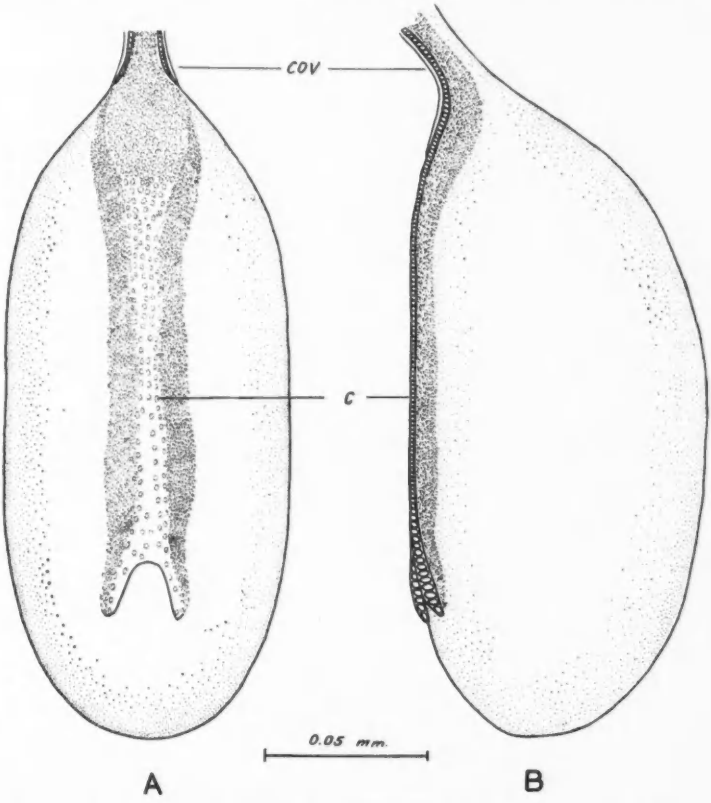

FIG. 3. Detail of "granulated" band. A. "Ventral" aspect. B. Lateral view. cov., thin covering occasionally visible.

point it is completely surrounded by the band. As nearly as could be determined without sectioning, this band is on the outside, except near the bulb end of the neck (Fig. 2, B). Here the "cells" underlie a thickened wall. Toward the end of the neck this covering disappears (Fig. 2, C) and the "cells" are again found on the surface. This covering may extend as a very thin layer over the neck and the upper part of the band on the main body of the egg. Frequently it appeared that the

band was situated under a thin layer at the junction of the neck with the egg (Fig. 3), although this may have been due to some microscopic effect and the existence of such a layer can only be confirmed by sectioning.

The ovaries are composed of six ovarioles, three to an ovary. Each ovariole contains two to three eggs by the second day after emergence and in a few days several more are formed. Six mated females confined in oviposition vials for two weeks with regular feedings of dilute honey contained at the end of this period from 22 to 30 ovarian eggs, an average of almost 25 per female. The eggs overlap in the ovarioles so that the bulb of one is immediately above the main body of the next.

Deposited egg.—During oviposition the contents of the bulb are forced into the egg proper. The collapsed bulb together with a portion of the neck are left protruding from the host and appear as a minute thread projecting from the surface.[4] This portion is usually erect but curved (Fig. 2, D). The thickened end of the collapsed bulb fits over the stalk like a cap. Usually the chorion of the host egg surrounds that portion of the stalk which has thickened walls, although sometimes in the act of depositing a second egg the stalk of the previously deposited egg is pulled out slightly. The remainder of the stalk within the host curves toward the center. The "granulated" portion of the stalk and of the egg proper become a shimmering silvery white immediately after deposition.

Soon after deposition melanization commences. Within thirty minutes at room temperature the thickened portion of the stalk is grayish. Five hours after deposition this portion has blackened; the "granulated" portion of the entire stalk and the upper part of the structure on the egg body are brown. The remainder of the upper part of the egg body has become light brown. Even though a portion or all of the thickened area of the stalk protrudes from the host, it also becomes black. After eclosion the entire egg shell eventually becomes light brown. This process may possibly be one of oxidation, for ovarian eggs dissected from a female that had died a week earlier were similarly colored.

LARVAL STAGES

First instar larva.—Approximately 24 hours after deposition an accumulation of yolk appears at the center of the egg. No further development is noticed until about the 40th hour when the indentation of the stomodaeum is apparent (Fig. 5, B) and the developed embryo begins moving. Shortly thereafter, air appears in the tracheal system, and within a few hours it is completely filled. By the 44th hour eclosion usually occurs. The larva protrudes from the free end of the egg, remaining with the caudal end enclosed by the persistent chorion (Fig. 5 A, C). The almost spherical larva has nine distinct segments exclusive of the head. A tenth barely protrudes from the egg shell. The other segments are indistinguishable. The mouth, the narrow fore-gut, and the large

[4]Eggs deposited in this manner have been termed "stalked eggs" and apparently these are limited to certain species of the family Encyrtidae.

mid-gut are apparent. The tracheal system is barely discernible at eclosion and invisible thereafter, probably because of the larva's minuteness and because of the opacity of the large mid-gut. The system can best be seen in mature embryos.

If an egg is dissected from the host immediately prior to eclosion, almost the entire tracheal system is visible. This instar and the succeeding two are metapneustic, each possessing a single pair of spiracles

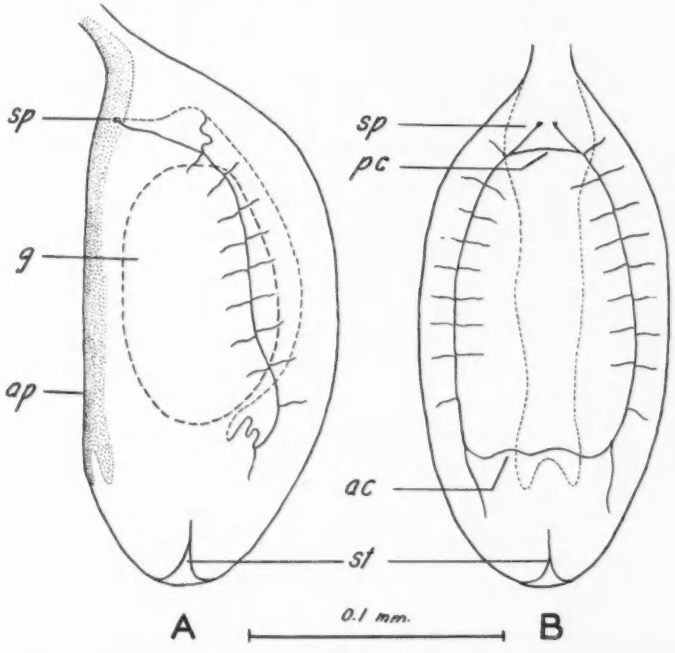

FIG. 4. The tracheal system of the mature embryo, showing its relationship with the "granulated" band. A. Lateral aspect. B. Dorsal aspect. ac., anterior commissure; g., mid-gut; pc., posterior commissure; sp., spiracles; st., indentation of stomadaeum.

situated near the end of the abdomen. Since the segmentation is obscure the segment bearing the spiracles could not be determined. In the primary larva they are firmly attached to the egg shell at the center section of the silvery area near the stalk. The observed structures are illustrated in Figure 4. The posterior commissure is short and its diameter is as great as that of the longitudinal tracheae; the anterior one is longer than the posterior commissure and about half its diameter. The lateral tracheae are very minute and difficult to discern.

The larva is almost spherical at eclosion, but prior to ecdysis it is approximately three and a half times as long as broad and the segmentation is less distinct (Fig. 6, A).

The mandibles (Fig. 6, B) are exceedingly minute, measuring slightly more than 0.009 mm.

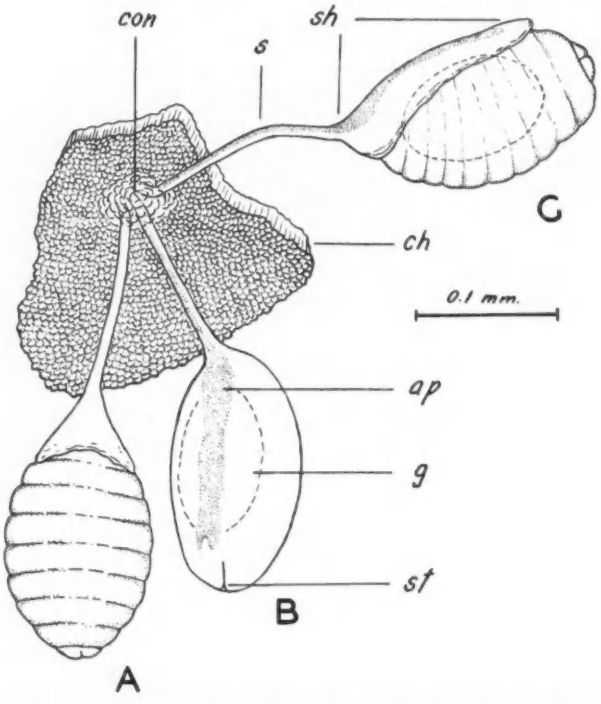

FIG. 5. Immature stages suspended within the host from the same puncture. A. Dorsal aspect of larva immediately after eclosion. B. Nearly mature embryo, showing the apparent mid-gut and the indentation of the stomodaeum. C. Lateral aspect of larva immediately after eclosion. ch., chorion of host (*Murgantia histrionica*); con., conglomeration of host material; s., portion of stalk extending within the egg; sh., persistent shell of parasite egg.

At ecdysis, the exuvia is gradually sloughed off to the posterior extremity and remains attached to the egg. Approximately 20 hours is required for this first larval stage to be completed.

Second instar larva.—The second instar larva is diagrammatically shown in Figure 6, G. There are ten distinct segments, exclusive of the head, and possibly additional segments are concealed by the egg shell and the exuvia of the first instar larva. The tracheal system is similar

to that of the first instar larva. The large cone-shaped spiracles (Fig. 6, F) are firmly attached to the band in approximately the same position as the spiracles of the first instar.

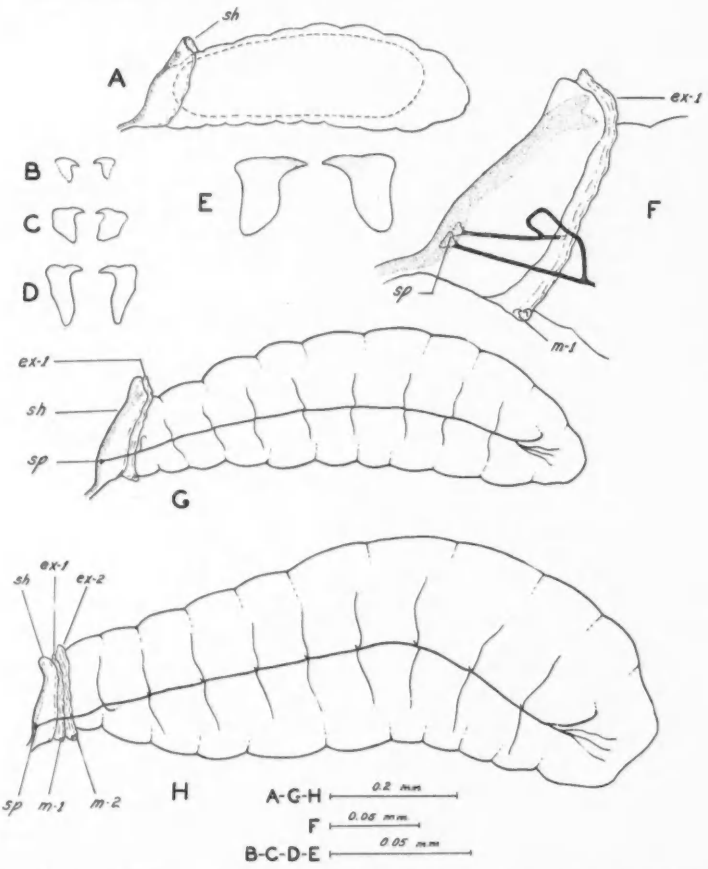

FIG. 6. A. First instar larva, shortly before ecdysis. B–E. Mandibles of the first, second, and third instar, respectively. F. Caudal extremity of the second instar larva enveloped by the persistent egg shell and the first larval exuvia. G. Second instar larva. H. Third instar larva. ex-1, ex-2, exuviae of respective larval instars; m-1, m-2, mandibles of respective larval instars.

The relative size of the mandibles is shown by the scale accompanying the figure (Fig. 6, C).

At ecdysis the exuvia is sloughed off to the posterior end and remains attached. The duration of this second larval stage is approximately the same as that of the first, 20 hours.

Third instar larva.—The third instar larva (Fig. 6, H) is very similar to the second. The posterior end of the larva remains enclosed in the envelope of the egg shell and the first and second larval exuviae. The spiracles are firmly attached within this envelope in the same locality as the previous instar's spiracles. In a few cases the spiracles of the second instar were seen within those of the third instar.

The mandibles are slightly larger than those of the previous instar (Fig. 6, D).

This stage is somewhat shorter than the others, approximately 16 hours. At its conclusion the exuvia appears to be only partially cast and remains as a covering for the fourth instar larva.

Fourth instar larva.—The fourth instar larva (Fig. 7) is noticeably different in shape and structure than the preceding instars. It is only about twice as long as broad. There are thirteen segments including the head. The last three abdominal segments are not as clearly defined as the remainder.

The most distinctive feature of this instar is the respiratory system. There are nine pairs of spiracles. Eight pairs are situated at the anterior of the second thoracic to sixth abdominal segments. The ninth pair is located at the posterior of the eighth abdominal segment and each spiracle is enclosed in a sort of cup-like arrangement (Fig. 7, B, C.) At the beginning of the stadium the posterior end of the larva is enclosed in an envelope composed of the egg shell and the 1st, 2nd, and 3rd exuviae. It is attached to the egg shell at the band, though not as firmly as the previous instars. The cup of each of the ninth pair of spiracles surrounds a stigma of the third instar and a portion of the collapsed trachea extends into the lumen of the spiracular branch. When the end of the abdomen is enclosed, the instar is still surrounded by fluids and the peripneustic system has no access to the free air. With some difficulty it was found that these spiracles are covered by a membrane which surrounds part of the insect's body. This membrane is very thin and transparent and does not appear to cover the head and the first thoracic segment. The covering is believed to be the third larval skin which has not been completely cast, and that it serves to protect the peripneustic tracheal system from the surrounding fluid.

As soon as the contents of the egg are consumed, the membrane covering the body, together with the posterior envelope, is cast off. Usually the egg stalk breaks at the inner surface of the host shell (occasionally the whole stalk is pulled into the host) or the larva slips away from the old egg and exuviae, leaving them intact. These remains are flattened against the chorion of the host and are frequently visible from the exterior as minute dark triangles. The eight pairs of spiracles that were covered by a membrane now have direct access to air. The ninth pair apparently becomes non-functional before the end of the stadium, as the connecting tracheae appear collapsed or are frequently filled with liquid.

The highly sclerotized tooth of the mandible measures 0.013 mm. The base is nearly transparent and never regular in shape.

A longer period is passed in this instar than any of the other larval stages. For twenty-four hours, or slightly less, the larva is attached to the envelope. An additional twenty-four hours is undergone as a free,

peripneustic larva in the empty, or nearly empty, shell of the host. As the prepupal stage is approached, the body contents gradually turn from a yellow color to a pale brown. Most of it is voided as meconium in the form of ovoid pellets which turn an orange-brown color and become flattened against each other on the sides of the egg.

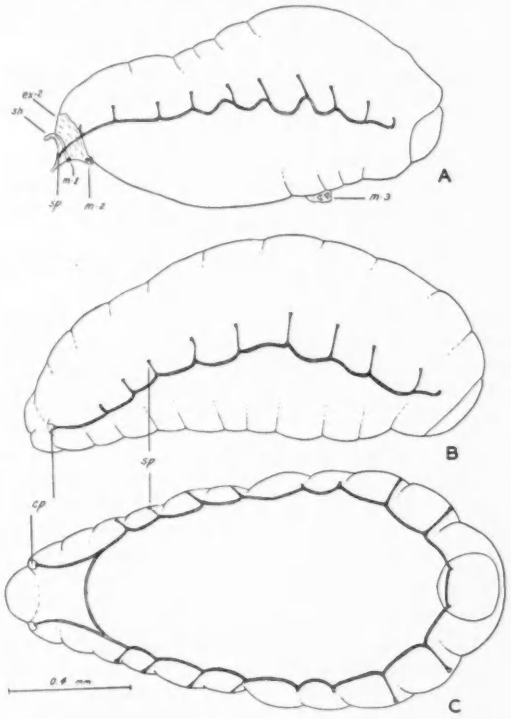

FIG. 7. Fourth instar larva. Secondary tracheae are omitted. A. Attached to the posterior envelope. Lateral aspect. B. Freed of posterior envelope. Lateral aspect. C. Same. Ventral aspect. The first and second pair of abdominal spiracles are more dorsal than the others and do not appear in this aspect. cp., "cup" enclosing ninth spiracle.

After voiding the meconium the insect is ivory white except for a portion of the yellow unconsumed food which remains in the center. The head and the thoracic segments lengthen, the abdominal segments contract, and folds appear where the legs are forming.

At ecdysis the fourth larval skin is pushed back to the posterior end and remains attached as a small, white, thread-like projection from the pupa. This prepupal period lasts about thirty-six hours from the time the last meconial pellet is discharged.

PUPAL STAGE

In a few hours after the last larval skin is shed the pupa becomes grayish and gradually turns opaque black. Approximately eight days is passed in this stage.

In all the observed instances where two pupae occurred together they were oriented vertically in the host, but headed in opposite directions. When only one was found in an egg, in the majority of cases the head was at the operculated end.

The imago emerges by gnawing a hole in the side or, less frequently, in the top of the chorion. When more than one are present, emergence is usually through the opening made by the first to mature.

PARTHENOGENESIS

Oöencyrtus johnsoni is arrhenotokous, that is, unmated females deposit eggs which yield only male progeny. Three unmated females were more reluctant to lay eggs the first few days after emergence than were three mated females of the same age. The total progeny of the fertilized and unfertilized females was on the average the same. (See Table 1).

NUMBER OF PROGENY AND PROPORTION OF SEXES

Three mated and three unmated females were each supplied every other day with host egg masses. The progeny were allowed to emerge and the undeposited eggs were counted after the death of the female. The results are shown in Table I. The largest number of progeny was 224 from an unmated female. The extent of superparasitism and the per cent of mortality was not ascertained.

Crossman found that the females of *O. kuvanae* greatly outnumber the males. This is also true of *O. johnsoni*. From 130 parasitized eggs obtained in the field, 279 adults were secured of which 221 were females and 58 males. Thus the proportion of females to males was about four to one. Laboratory experiments did not confirm this observation. The ratios of females to males of the progeny of the three mated females (see Table 1) were 5.5 : 1, 7.9 : 1 and 1.9 : 1 respectively. The last mentioned ratio is that of the progeny of a female which produced only males in the last two exposures to the host; 16 emerged from 8 parasitized eggs and 6 from 4 parasitized eggs. It is obvious, therefore, that more experiments are necessary. In such experiments the mortality factor and the number of undeposited eggs must be considered.

SUPERPARASITISM

Oöencyrtus johnsoni normally deposits from one to three eggs in a host. In confinement a female may deposit twice in the same egg or another female may parasitize the same egg. As many as eight eggs have been found in a single host. Crossman examined hundreds of thousands of eggs of the gipsy moth parasitized by *O. kuvanae* and observed only a very few cases of more than one developing in a host, although it may oviposit more than once. Several adults of *O. johnsoni* may develop in one host. Five pupae were found in two instances and four pupae in two others. As was expected these pupae were small, but both sexes were represented in each case.

It is rare for all eggs to develop and mature, e. g., in one host eight egg stalks were found, yet only two larvae matured, and in another four stalks occurred, yet only one larva had matured. To determine the degree of superparasitism, eggs were parasitized and re-exposed three to four days afterwards. Upon dissection, after four days incubation it was found that:

1 host contained 1 prepupa and 4 stalks.
2 hosts contained 2 prepupae and 5 stalks.
1 host contained 3 prepupae and 4 stalks.
1 host contained 3 prepupae and 5 stalks.
1 host contained 4 prepupae and 7 stalks.

Examination of the remains revealed that second and third instar larvae had been destroyed. In one egg parasitized at the second exposure only the larvae were in the third and fourth stage. From this experiment and from miscellaneous observations, it appears, when more than one egg is deposited in a host by the same or other females, (1) that the number of larvae which will mature depends upon their relative ages, and (2) that the maximum number which are able to develop is five. That is, if the larvae are of quite different ages and there are from two to five present, the older consume the younger, and likewise, if all the larvae are in the same stage, all over the number of five are consumed. Superparasitism due to age differences may be accounted for on a purely physical basis. Fourth instar larvae, in order to make use of their peripneustic tracheal system, require that the host be depleted of all fluid and to obtain that end consume the food material. Consequently, first, second, and third instar larvae are killed by starvation or as a direct result of the loss of surrounding liquid, and are consumed.

Females of this species are able to distinguish to a certain extent parasitized from unparasitized eggs, i. e., usually they prefer to avoid an egg occupied by their own kind. However, in several instances when confined, a female has been observed to oviposit in an egg previously parasitized (on the same or previous day) by herself or other females even if unparasitized eggs were available. Under the same conditions one female will attack a host already being parasitized by another female. When an egg contains developing larvae, an apparant "uneasiness" is exhibited. They commence to attack an egg, then forsake it to try another, only to return later. Hours may be spent drilling on one egg and much time is consumed running over the egg mass and about the oviposition vial.

The species will not oviposit in hosts containing mature larvae of their own kind.

LIFE CYCLE AND SEASONAL HISTORY

In the insectary with an average temperature of 78° F, the incubation period of the eggs did not exceed three days. First instar larvae were found throughout the third day and by the end of the third and the beginning of the fourth day second instar larvae were recovered. The relatively short third stage occurred between the middle of the fourth day and early in the fifth. During the fifth day the fourth instar larvae were noted attached to the posterior envelope, but on the sixth

they were free. Thus, in four days four instars were undergone. The prepupal period, which lasted about a day and a half, was followed by the pupal period of seven days duration. Sixteen and seventeen days after oviposition the imagoes emerged. Allowing one day for the maturation of the eggs, the total life cycle was usually eighteen days. In the field under coastal conditions, the period is probably twenty days at the least. J. C. Elmore found the minimum time in the laboratory to be 24 days and the maximum 111 days with an average of 30 days during the summer. Walker and Anderson (1933) found that the species completed its life cycle in 16 to 17 days. In the cooler months the period would be longer; Elmore reports 68–111 days during January and February in the laboratory.

No attempt was made to ascertain the seasonal behavior of *O. johnsoni*. Essig (1922) found it in greatest numbers during July. Walker and Anderson recorded 35% to 55% parasitism in August and September in east Virginia. The parasite was noted in the same state by White and Brannon (1933) from the first part of July to mid-September and it attained approximately 50% parasitism in the latter part of August. J. C. Elmore collected specimens as early as the 23rd of June in 1925. The writer obtained abundant material from a similar locality late in July, 1936, through August and September; as late as November 4th, parasitized eggs were available.

The wintering habits of *O. johnsoni* or of the harlequin bug in the coastal areas of southern California have not been investigated. White and Brannon have determined that all stages of the cabbage bug may be found in February as far north as eastern Virginia during exceptionally mild winters. They believed that it may be active the entire winter farther south, but noted that in the northern parts of the infested territories true hibernation apparently occurred. In the localities where the host breeds most of the year around it is possible that *O. johnsoni* does likewise. Such hibernation as occurs may be in immature stages within the host, although *O. kuvanae* will overwinter as an imago.

There are several generations of *O. johnsoni* in a year. The cabbage bug has been estimated by White and Brannon to have two generations and a partial third in most of its range, all stages being found in the field during the growing season. Since the life cycle, as reported by these workers, requires 40 to 60 days and that of the parasite probably 20 to 30 days under similar conditions, there would be on the basis of comparison two generations of the parasite for each one of the host. Since the host's generations are uneven, the parasite may breed almost continuously. There is some doubt that the parasite would be as abundant where there are fewer and more regular generations of the harlequin bug.

FOOD HABITS OF ADULT AND LONGEVITY

Crossman has noticed adult *Oöencyrtus kuvanae* apparently feeding at the punctures made by their ovipositors in gipsy moth eggs. During the process of ovipositing in the harlequin bug eggs the females of *O. johnsoni* invariably consume the liquid that is "pumped" from the puncture. Some parasites, especially pteromalids (Flanders 1935), require this material from the host before any of the ovarian follicles are

able to mature. Apparently this diet is not so essential as in pteromalids for the reproduction of *O. johnsoni*, since fully developed eggs are formed on the day of emergence.

No experiments were planned with the objective of determining the longevity of this species and the data secured were incidental to the progeny experiments (see Table 1). In these experiments six females, 3 mated and 3 unmated, were placed singly in oviposition vials, fed periodically with dilute honey, and supplied with egg masses every other day. During the latter part of August, and throughout September and October at room temperature, the mated females lived 20, 21, and 22 days respectively. Of the unmated females one lived 20 days and another 23 days. The third female lived during the succeeding months and was still living at the end of 116 days. During the early periods of the experiment there were some days when the average temperature outside was considerably higher than in the later periods, which may account for the early mortality of the five females.

EFFECT OF PARASITISM ON APPEARANCE OF HOST

To the casual observer parasitized eggs apparently do not differ from healthy eggs. The distinction can usually be made if the semi-transparent caudal end of the eggs is examined. Newly deposited eggs of the harlequin bug are light yellow, but as development proceeds, the general color becomes orange which is apparent even at the operculated end. Since punctured eggs fail to develop, the eggs retain the color of the stage of development in which they were parasitized. After approximately five days the stalk and the melanized triangle of the egg shell and exuviae occasionally may be seen adhering to the inner surface of the egg. The general color of the egg at this time is also orange. Within two or three days the orange-brown meconium is visible. Soon some of the contents appear black from the developing pupae. The unparasitized hosts usually hatch on or before this time, but the parasite does not emerge for several days.

Separation by color is not infallible for the differences are not always marked (at least not until the unparasitized hosts are almost developed) and since punctured host eggs containing no parasites may show the same coloration as unpunctured eggs.

ECONOMIC IMPORTANCE

Only in recent years has *Oöencyrtus johnsoni* received much notice as a parasite of the harlequin cabbage bug, *Murgantia histrionica*. Walker and Anderson found in east Virginia that 35% to 55% of all eggs collected in August and September were parasitized. White and Brannon state: "There are three known parasites of the eggs, *Trissolcus murgantiae* Ashm., *Trissolcus podisi* Ashm., and *Oöencyrtus johnsoni* How.; but so far as has been observed, they never become abundant enough throughout the infested territory to serve as a natural means of control of this pest. One of these, *O. johnsoni*, however, appeared to be of considerable value in eastern Virginia during the unusually severe harlequin-bug outbreak of 1932." Eggs collected in the field late in August were 50% parasitized. From this observation they concluded

that possibly "under favorable conditions this parasite may prove to be highly beneficial in some parts of the south." In Florida, however, Drake (1920) found that only 5% to 10% of *Murgantia histrionica* eggs collected in July and August were destroyed by *Trissolcus murgantiae*, a proctotrupid, and *Oöencyrtus johnsoni*.

On September 12th, 1936, the writer collected 202 *Murgantia* eggs from wild bladder-pod, *Isomeris arborea* Nutt., at the edge of a slough near Costa Mesa, California. Of these 69 hatched, 3 failed to hatch, and 130 were parasitized. Thus, in that season and locality, 64% plus of the cabbage bug eggs were parasitized. Continuous seasonal studies were not made, hence the effect upon the population density was not determined. No other egg parasites were reared.

The harlequin cabbage bug is not encountered as a pest of any consequence in this state and is usually noted only as a frequenter of weeds, notably mustard (*Brassica* spp.). It is doubtful that this parasite is for the most part responsible for the low density of its host. However, in an unpublished manuscript, J. C. Elmore states that "Undoubtedly the parasites have a very marked effect upon the abundance of *Murgantia histrionica*." In the East where the bug is a common pest, *O. johnsoni* has not apparently kept the host below the point of economic damage However, these areas may be less favorable for the parasite than for the host.

THE ROLE OF THE EGG SHELL IN THE RESPIRATION OF CERTAIN ENCYRTID LARVAE

The existence of a double-bodied ovarian egg and a stalked deposited egg in an encyrtid was first demonstrated by Embleton (1904) for *Encyrtus* (*Comys*) *infelix* (Embleton). In addition to observing these features of the egg she described a portion of the stalk as having "an appearance of fine papillations or striations on the wall of the tube" which was more conspicuous in the deposited egg. This description, correlated with recent investigations, indicates that Miss Embleton undoubtedly observed the structure that is now known as the aeroscopic plate.[5] A relationship between stalked eggs and the respiration of young larvae was reported by Howard and Fiske (1911). The larvae of *Oöencyrtus* (*Schedius*) *kuvanae* (Howard) were noted to remain with the posterior end enclosed by the egg shell. It was believed that the hollow stalk served to supply a connection with the outer air. A similar egg-larva relationship was found to exist by Timberlake (1913) in *Microterys flavus* (Howard). However, Imms (1918) was the first to describe a metapneustic tracheal system existing under such a relationship, as is found in the young larvae of *Blastothrix sericea*

[5]This term, suggested by Silvestri (1919), for the reticulations on the egg proper, is used here to indicate the entire structure on the egg surface.

(Dalm.) (*B. britannica* Gir.). Silvestri (1919) gave illustrations and descriptions of the eggs of five species of encyrtid parasites of Coccidae.[6] These eggs were characterized by the peculiar structures here described and illustrated for the eggs of *Oöencyrtus johnsoni*. When Silvestri examined the deposited eggs of one of the species in physiological liquid or glycerine, a blackish color was noted to extend the length of the petiole and the dorsal plate. He assumed this appearance to be due to the presence of air. Four of the five species were observed to possess metapneustic larvae with their posterior extremities enveloped by the chorion of the egg. The envelope, which he called the respiratory hood, was augmented by the accumulation of the successive larval exuviae. This hood was in communication with the exterior of the host by means of the petiole at the end of which was located a porous or spongy structure, the respiratory plug. (See Fig. 8, r. p.). These eggs were called tracheated eggs. The plug was assumed to be of membranous structure, permitting the osmotic passage of air presumably into the petiole which functioned as a tracheal tube. By this arrangement, according to Silvestri, the larva was enabled to respire atmospheric air. The reticulations on the dorsal side of the egg served as an aeroscopic membrane or plate, but apparently no respiratory function was ascribed to it. The spiracles of the first instar larvae of two species were said to adhere to the dorsal part of the egg shell, but in only one of these species were the spiracles described or illustrated as adherent to the plate. If Silvestri had considered the plate to be of respiratory significance, he undoubtedly would have drawn the tracheae of the larvae of all of the species as leading to the plate.

Subsequent to Silvestri's observations, many authors have recorded metapneustic tracheal systems for the larvae of several species of encyrtids and have also concluded that respiration of atmospheric air was by means of the hollow egg-stalk. Unlike Silvestri, they assumed that the lumen of the petiole opened directly to the outside air. Several of these investigators have figured and occasionally described structures which resemble those found by Silvestri. Upon examining the eggs of *Metaphycus lounsburyi* (How.), Smith and Compere

[6] *Aphycus melanostomatus* Timb. [*A. punctipes* (Dalm.)]; *Blastothrix sericea* (Dalm.); *Microterys masii* Silv.; *Encyrtus infidus* (Rossi); *Phaenodiscus aeneus* (Dalm.).

(1920) found what they termed "a ventral rib or stay" which extended about two-thirds the length of the egg and appeared to be a prolongation of the stalk. This "rib" was assumed to give rigidity when the egg was being inflated. It was noted that the stalk became dense white after deposition. These authors, in a subsequent publication (1928), illustrated a deposited egg of this species which clearly shows on the egg a structure very similar to the plates sketched by Silvestri. In this article no function was ascribed to the structure. Compere (1924) has figured a deposited egg of *Anicetus annulatus* Timb. which indicates that this species may possess a plate, and in 1931 he illustrated the eggs of *Diversinervus elegans* Silv., which even more closely resemble Silvestri's illustrations. Ishii (1932) noted the caudal appendages of *Encyrtus barbatus* Timb. attached to the egg shell. A structure, not unlike a plate, may be noted on Ishii's illustration of the deposited eggs of *Microterys clauseni* Comp. Clausen (1932) undoubtedly observed the structure on the eggs of *Encyrtus infidus* (Rossi). He described what appeared to be a waxy incrustation on the dorsal side of the stalk and on a portion of the egg, but no function was assigned to it. Recently Thorpe (1936) has found the caudal processes of the larva of *Encyrtus infelix* firmly fastened to the chorion of the egg near the stalk at the extremity of an area which he described as "a finely shagreened band . . ." The chorion in this region appeared ". . . to be of a spongy nature." He ascribed no function to this arrangement and maintained that the larva utilized atmospheric air obtained by the hollow stalk.

In the course of studying the biology of parasites introduced from South America in 1935, S. E. Flanders, of the Citrus Experiment Station, observed a white elongate area on the eggs of *Leptomastix dactylopii* Howard, a parasite of *Pseudococcus citri* (Risso). Since the white or silvery color gradually, yet irregularly, disappeared when the eggs were compressed in Hoyer's solution, he concluded that the appearance was due to air contained in that portion of the egg shell. Searching the literature for a similar phenomenon, he noted that Silvestri had arrived at the same conclusion nearly eighteen years earlier.

Flanders noted the young larvae of *Leptomastix dactylopii* to have their spiracles firmly attached to the aeroscopic plate. The writer, while making a survey of the parasite fauna of

mealybugs, noted a similar vital connection between the eggs and young larvae of *Anagyrus yuccae* (Coq.), a parasite of *Puto yuccae* (Coq.). Since then he has examined the eggs and larvae of many species of encyrtids, and in several cases a similar arrangement was found to exist.

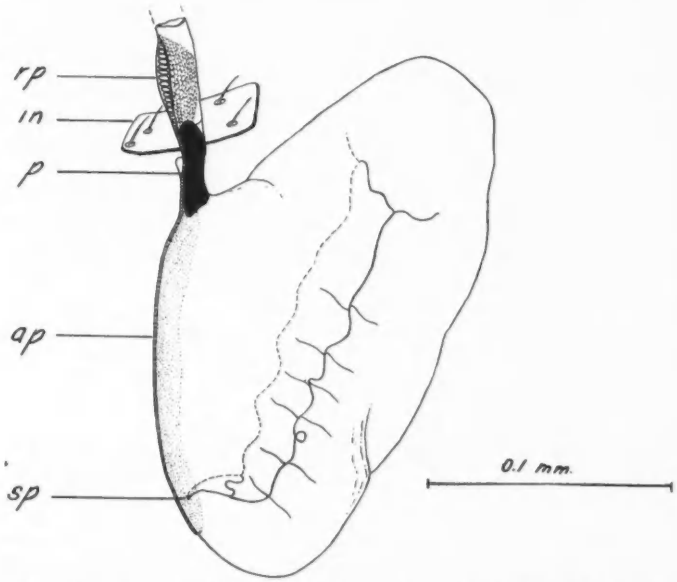

FIG. 8. *Anagyrus yuccae* (Coq.). First instar larva shortly after eclosion. Note position of spiracles. The collapsed bulb is not indicated. in., integument of host, *Puto yuccae* (Coq.); p., solid, opaque plug in lumen of stalk; rp., larger "cells" of neck, the "respiratory plug" of Silvestri.

THE AEROSCOPIC PLATE AS THE MEANS OF OBTAINING ATMOSPHERIC AIR

On the basis of the observations concerning the eggs and larvae of *Oöencyrtus johnsoni* and miscellaneous investigations of the stages in other encyrtids, the writer believes that the banded structure found on the eggs of certain species, and not the hollow stalk, serves to conduct atmospheric air for the respiration of the larva. The following observations are presented in support of this hypothesis. Some of the evidence, it is admitted, is circumstantial.

1. *The presence of air within the plate.*—Immediately after deposition the finely reticulated area of the egg and stalk is a white or a silvery color by reflected light and gray by transmitted light, whereas the ovarian egg does not exhibit these appearances. (The blackish color of the plate in freshly deposited eggs has already been noted by Silvestri). The area on the egg of *Encyrtus infelix* (Embl.)[7] is visible only when the egg is in the deposited state, because of the silvery sheen (Fig. 9, A). When immersed in Hoyer's solution, the silvery areas were observed to be gradually replaced. The fluid advances spasmodically from any suture, i. e., it does not progress for a few moments, then suddenly it advances in an irregular fashion over several of the "cells" or reticulations. This appearance and behavior is similar to those exhibited by air within insect tracheae. The lumen of the stalk contains no air as the characteristic silvery sheen occurs only in the reticulations.

2. *The location of the spiracles.*—Invariably the spiracles are located flush against this silvery area on the egg proper. In most cases they are firmly attached to the band[8] and the larva can not be dislodged without their destruction. In no case have the spiracles been situated directly at the attachment of the stalk to the egg, nor have any tracheal trunks been observed to extend into the stalk.

Perhaps the strongest evidence in support of this contention is that the larvae of *Anagyrus yuccae* have the spiracles firmly attached at the base of the plate at the opposite end of the egg from the hollow stalk (Fig. 8). The respiration of atmospheric air by any other means would appear impossible.

3. *The blocking of the lumen of the stalk in some species.*—Thorpe observed the stalk of *Encyrtus infelix* to contain a dark body which he assumed to be a remnant of the protoplasm of the bulb. He states that this mass partially plugged the stalk. However, the deposited eggs of *Anagyrus yuccae* and *Leptomastix dactylopii* appear definitely to be stoppered by this dark body. It would seem, then, impossible for any atmospheric air to proceed down the hollow stalk of the deposited eggs of these species.

4. *The absence of any discernible aperture into the lumen of the stalk.*—Almost invariably the collapsed bulb of the egg of *Oöencyrtus johnsoni* remains attached to the stalk of the deposited egg. This body also is for the most part found intact on the deposited egg of *Encyrtus infelix*, in which it hangs like a semaphore from the erect stalk (Fig. 9, A). If newly deposited eggs of both of these species are dissected and compressed under a cover-glass, the collapsed bulbs will again inflate. Silvestri clearly shows these bulbs in his illustrations of the deposited eggs of other encyrtids. In those instances observed by the writer in which the bodies are not broken off, no aperture into the lumen of the stalk is apparent. In *Encyrtus infelix* the bulb is frequently twisted or pinched at its junction with the neck. It would seem, therefore, that atmospheric air must enter by some other opening if the larvae are to utilize it.

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[7]Determined by P. H. Timberlake.

[8]Both Silvestri and Thorpe have noted this attachment in other species.

5. ***An apparent correlation between the structure of the egg and the type of tracheal system.***—The eggs of *Anagyrus* sp., a parasite of *Phenacoccus solani* Ferris, do not possess aeroscopic plates, although the deposited eggs are suspended from the integument. The neck and bulb do not protrude erect from the host but are collapsed on the surface. The larva develops free of the egg and is not provided with spiracles. On the

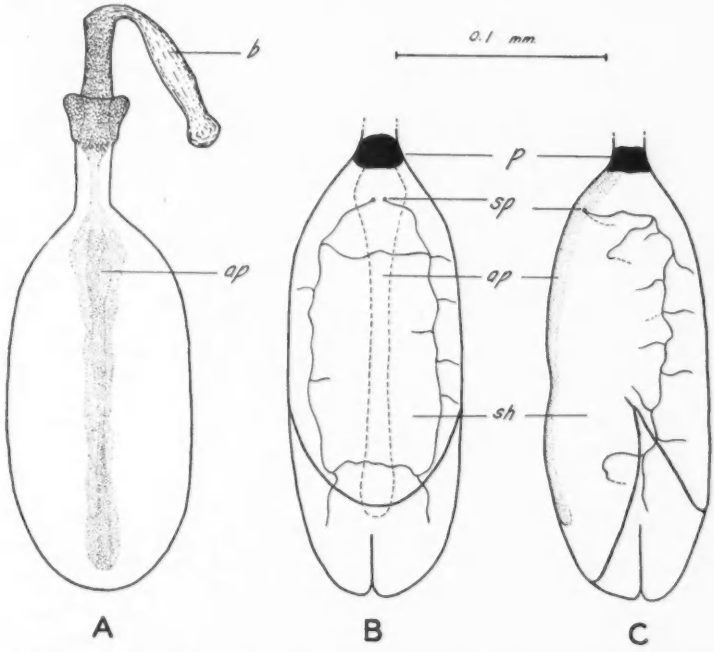

FIG. 9. *Encyrtus infelix* (Embl.). A. Deposited egg. The center of the aeroscopic plate is composed of larger "cells" than the rest of the structure. These "cells" are much smaller than those on the eggs of *Oöencyrtus johnsoni*. B. First instar larva, shortly after eclosion. Dorsal aspect. The plug is not as solid as shown since it disintegrates with pressure. C. Same. Lateral view; b., collapsed bulb.

other hand, the eggs of *A. yuccae* are plated, and the larvae are metapneustic. Similar observations have been made by D. W. Clancy for the eggs and larvae of two species of *Isodromus* parasitic on *Chrysopa* larvae. *I. niger* Ashm. possesses both the plated eggs and the metapneustic larvae, whereas the eggs of *I. iceryae* Howard have no such structure and the primary larvae are without spiracles.

Although it may appear that metapneustic larvae hatch only from eggs possessing aeroscopic plates, there is recorded one exception. Sil-

vestri observed the eggs of *Aphycus punctipes* (Dalm.)[9] to have a prominent plate and in the deposited state was attached to the integument of the host. Although the first instar larva remained with the posterior end encapsulated by the chorion, Silvestri found it to be devoid of spiracles. There may be two interpretations of this observation: (1) the spiracles are so minute that they were overlooked by Silvestri, or (2) the larva is an intermediate form in which the spiracles have disappeared, despite the retention of the egg structure. The first is unlikely because of Silvestri's keen observations on other encyrtid species and since Imms, as well, failed to find spiracles in supposedly the same species. No structure remotely resembling an aeroscopic plate was described by Imms. If the second interpretation is accepted, then the conception must be broadened to include the exception. However, there is as yet no conclusive evidence to contradict the statement that encyrtid larvae exhibiting metapneustic tracheal systems have hatched from "tracheated eggs," even though the converse may not be true.

6. *Penetration of the egg by stained oils.*—By immersing the entire host in "a thin vegetable oil" which had been strongly stained with a dye "such as Sudan III," Thorpe endeavored to prove that the first instar larva of *Encyrtus infelix* was enabled to utilize atmospheric air by means of the hollow stalk. The colored oil speedily entered the egg stalk and invaded the tracheal system of the larva. The writer sought to duplicate this experiment and encountered difficulty in securing an oil that not only would penetrate speedily but also could be stained sufficiently dark so as to be readily observable in the minute structures involved. Mediocre results were obtainable with equal parts of kerosene and xylene saturated with Oil Red O (Sudan II). This stain colored the oils much darker than either Sudan III or IV. The results were not always consistent and a more suitable oil is highly desirable. Pending further investigation, present observations may be regarded as a supporting the contention that air may enter by means of the plate.

The parasitized egg of the cabbage bug was immersed from one to five minutes in the stained oils. Then it was removed, rolled on a paper towel to remove as much of the oils as possible from the surface, and dissected in normal salt solution. If any oil was observable within the host, it was discarded, but if none had penetrated, the eggs of the parasite were carefully removed intact and observed unmounted. Those eggs in which any stain was discernible were mounted in the normal salt solution or in glycerine. If the petiole and bulb were not intact, the egg was likewise disregarded since there was no certainty that the stalk had not been broken prior to or during the immersion and consequently had permitted the stain to enter the lumen of the stalk. In the several cases of penetration the stain was apparent in the "granulated" area only; none was in the bulb, the lumen of the stalk, nor within the egg. The plate had been penetrated to its very end. Only the outer margins of the structure on the egg were filled by the colored

[9]P. H. Timberlake informs me that this species is undoubtedly *Aphycus melanostomatus* Timb., and was incorrectly synonomized with *A. punctipes*. The two are distinct and on the basis of Silvestri's description of the adult, the immature stages of *A. melanostomatus* were observed and not those of *A. punctipes*.

oil with one minute immersions. After a longer period of time, the oil entered the center section which had a darker color indicating that the "cells" are thicker at this point. If the tracheal system of the embryo were developed or the larva had just hatched, the trunks and the commissures were invaded. It is peculiar that the stain did not penetrate at all into other eggs within the same host. Nevertheless, in those few instances of invasion, it was not apparent that the oil had entered by any other means. The bulbs in all cases were intact. Due to the melanization of the "granulated" area the stain was not visible in that portion of the petiole. It is significant that no color was evident elsewhere which tends to indicate that the lumen had no part in the conduction.

Repeating the procedure with *Saissetia hemisphaerica* (Targ.), which had been parasitized by *Encyrtus infelix*, the same results were obtained. In this species it was more apparent that no oil entered the bulb.[10] Because of the abbreviated petiole, the slight melanization of that portion within the host, and the minuteness of the band, it was not as obvious that none had entered the lumen. Still, no color was discernible below the plug except in the plate and the tracheal system of the larva. Thus, with some degree of certainty, it may be stated that the oil had not penetrated the lumen of the stalk, for it could not pass beyond the plug even though it had entered. This is directly opposed to the experimental results obtained by Thorpe and the conclusions derived by him.

METHODS BY WHICH AIR MAY ENTER THE AEROSCOPIC PLATE

If the aeroscopic plate serves as a source of atmospheric air, it may well be asked, "How does air get into the plate?" While the egg in the ovaries does not have a silvery sheen in the banded area, immediately after deposition this appearance is usually prominent. If the assumption is correct that this appearance is due to air, the air must have entered at the moment of deposition. It is possible on the basis of the above evidence to make a few suppositions. In passing down the ovipositor the eggs are undoubtedly compressed. The plate is in the nature of a sponge which is emptied of any fluids by this compression. As the egg is deposited, the "sponge" swells to its former shape because of the elasticity of the "cell" divisions. The surface of the plate is impervious to the fluids of the host and therefore a vacuum exists. When the end of the stalk leaves the ovipositor, air rushes in and disperses throughout the structure. This would imply that the "cells" of the band are open to the atmosphere at the extreme end of the stalk only. It has been shown that at least a portion of the stalk of *O. johnsoni* is covered; the remainder of the band on the stalk and egg may be covered as well. However, there is little reason to suppose that the structure of the plate at the apex of the stalk is any different from that of the rest of the "granulated" area, and since the plate is impervious to host fluids, it cannot be entirely composed of open "cells." If it is conceived

[10]Clove oil stained with Oil Red O sometimes shows this result very effectively in this species.

as a membrane for gaseous exchange, atmospheric air must diffuse into the "cells" and then down the plate rather than into the lumen of the petiole, as Silvestri apparently believed.

The nature of the inner structure of the plate is equally vague. It is probably not a tube because of the irregularity with which fluid progresses; nor is it a series of intercommunicating cells, for if this were the case, air would be much slower in penetrating. It may be considered as a corrugated membrane, the "cells" being the corrugations which extend inwards and serve to distend the plate.

It is apparent that before any definite theory may be advanced as to the physical phenomena involved in the ingress of air within the plate the morphology of the structure must be better understood.

CONCLUSIONS

On the basis of present observations it may be concluded that the young larvae of *Oöencyrtus johnsoni*, and probably other species of encyrtids possessing stalked eggs and metapneustic larvae, may utilize atmospheric air by means of the peculiar structure of the egg shell. However, it has yet to be conclusively demonstrated that the larvae respire atmospheric air or even require it for development. Sufficient air may be derived by diffusion from the body fluids of the host through the body surface of the larva or through the aeroscopic plate and thence into the spiracles.

The physiology of respiration of metapneustic encyrtid larvae and the comparative morphology of the aeroscopic plate are being thoroughly investigated. It is hoped that this investigation will reveal the solution of some of these problems.

SUMMARY

Oöencyrtus johnsoni is an encyrtid parasite of the eggs of *Murgantia histrionica*. It is apparently an endemic species.

Mating may be accomplished immediately after emergence and eggs may be deposited that same day.

The deposition of the egg is a complicated procedure which requires a minimum of forty-seven minutes to complete. The significance of certain phases of the procedure is discussed. From one to three eggs are deposited in a host, but ordinarily two are found. Eggs in most any stage of development are attacked.

The egg is double-bodied and when deposited the smaller body, together with a portion of the neck, is collapsed and protrudes from the host. There is an area on a portion of the stalk and the larger body which appears granulated and is composed of a mosaic of "cells." This structure has the appearance of tracheae that contain air.

There are four larval instars. The first three possess a metapneustic tracheal system and remain attached to the persistent egg shell at the granulated band. The fourth instar is peripneustic. It is at first attached to the egg shell and eight pairs of spiracles are covered by a membrane, which appears to be the third larval skin. After a time this membrane and the egg shell with the enclosing exuviae of the previous instars are cast off. As many as five larvae will develop in one egg. Four days are required for larval development; thirty-six hours is passed as a prepupa and seven days as a pupa. The life cycle is approximately seventeen days. There are probably two generations for one of the host.

The species is arrhenotokous. The females outnumber the males almost four to one.

The female invariably feeds on material "pumped" from the egg, but this food is not necessary for the maturation of the eggs. One female was still living and depositing eggs after 116 days.

The species is not believed to be very effective economically.

The "granulated" band is believed to conduct atmospheric air for the metapneustic larvae of encyrtids. The phenomenon of metapneustic tracheal systems in Encyrtidae as reported by other authors is discussed and evidence is presented which indicate that this band, and not the hollow stalk, may conduct atmospheric air. Suggestions are made as to the methods by which air may enter the structure.

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FRAGMENTS OF ENTOMOLOGICAL HISTORY by HERBERT OSBORN. 1937. Pages i–viii + 1–394 (including 48 plates). Published by the Spahr & Glenn Company, Columbus, Ohio. Price, $5.00.

Owing to the lateness of the appearance of this comprehensive and very thoroughly illustrated history of entomology in America we are compelled to defer a more detailed review to a later issue of the ANNALS.—C. H. K.

APHIS TRANSMITTAL OF COMMELINA NUDIFLORA LINNAEUS MOSAIC TO PINEAPPLE[1]

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Although a mosaic of *Commelina nudiflora* Linnaeus has been known in Hawaii for many years it has not, except for a passing reference by Kunkel in 1921 (4) been noted in the literature.

According to Doolittle (2), Doolittle and Wellman (3) and Wellman (6) a similar disease occurring in Florida is transmitted by *Aphis gossypii* Glover and *A. maidis* Fitch. and in addition to these, Wellman advises[2] that *Myzus persicae* (Sulz.) and *Macrosiphum solanifolii* (Ashm.) are also transmitters.

Since all these aphis species occur in Hawaii it was readily determined that the disease on *C. nudiflora* in Hawaii was aphis transmitted, and (with the exception of *A. maidis*) by the same species of aphis. This last species of aphis has not transferred readily from the wild grasses to *C. nudiflora* so adequate tests of its transmitting ability have not been possible.

Thus far, only one insect-transmitted virus of pineapple (yellow spot by *Thrips tabaci* Lind.) has been recorded (5), although the mechanical transmission of *C. nudiflora* mosaic to pineapple was recorded by the writer in 1935 (1). There is apparently no previous record of the pineapple plant as a host for aphis.

MATERIAL AND METHODS

A colony of *Aphis gossypii* from an hibiscus bud was transferred to healthy *C. nudiflora* and maintained thereon for 3 months. No disease developed on the *C. nudiflora*. A portion of the colony was then transferred to diseased *C. nudiflora* and after 10 days transferred back to healthy *C. nudiflora*. In this manner healthy aphis colonies and colonies of positively viruliferous aphis were obtained.

The same general procedure was followed with *Myzus persicae* and *Macrosiphum solanifolii*.

Pineapple plants used were principally seedlings although some experiments were performed with Smooth Cayenne plants typical of those grown commercially.

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[1]Published with the approval of the Director as Technical Paper No. 92 of the Pineapple Experiment Station, University of Hawaii.

[2]Personal communication.

Transfer of aphis-infested *C. nudiflora* leaves was generally more effective than was brush transfer and the first-named method has been more freely used. All infestations were gross, that is, heavily infested leaves were transferred without attempting to transfer exactly equal numbers to each pineapple plant.

Production of winged forms was extremely rare in colonies of aphis grown on *C. nudiflora* in cages, particularly in the case of *A. gossypii* which was the species most commonly used. With this last-named species the production of alates could be stimulated by introducing a plant of *Bidens pilosa* L. into the cage. Alates are produced freely on this plant and transfer readily to the *C. nudiflora* growing in the same cage. No advantage with respect to disease transmission was noted in the case of the alate forms, so apterae were generally used.

TRANSMISSION EXPERIMENTS

These experiments are tabulated in Table I.

TABLE I. Aphis transmission of *C. nudiflora* mosaic to pineapple plants

APHIS SPECIES	NO. OF PLANTS USED	DATE OF INFESTATION	FIRST SYMPTOM APPEARANCE		TOTAL NO. OF PLANTS AFFECTED	NOTES
			Date	No.		
Aphis gossypii..	20	6-30-34	7-17-34	.....	1 doubtful case	Small seedlings under glass jars.
" "	42	3-23-35	4- 3-35	17	.....	Small seedlings in flat.
			4-16-35	23	40	
" "	5	4- 3-35	4-17-35	.....	1	Field grown tops.
Myzus persicae..	10	4- 3-35	4-12-35	1	.....	Small seedlings in flat.
			5- 2-35	4	5	
Macrosiphum solanifolii....	10	4- 3-35	4-12-35	4	.....	Small seedlings in flat.
			5- 2-35	1		
			6- 1-35	3	8	
Aphis gossypii..	14	4- 6-35	.....	.....	None	Field infestation of inflorescences.
" "	33	4- 9-35	.....	.....	"	Field infestation of inflorescences.
" "	40	4- 9-35	.....	.....	"	Young growing slips in field.
" "	15	4-18-35	4-25-35	2	.....	Young seedlings.
			4-30-35	2		
			5-14-35	2	6	
" "	10	4-26-35	5- 6-35	6	.....	Young seedlings.
			5-10-35	3		
			6- 3-35	1	10	
Myzus persicae..	10	4-26-35	5- 6-35	1	.....	Young seedlings.
			5-10-35	2		
			5- 3-35	1	4	
Macrosiphum solanifolii.....	10	4-26-35	5- 6-35	1	.....	Young seedlings.
			6- 3-35	1	2	
Aphis gossypii..	23	1-31-36	2-18-36	5	.....	Large seedlings.
			3-20-36	1	6	
" "	14	3-23-36	4-10-36	4	.....	Large seedlings.
			4-20-36	4	8	

DISCUSSION

It is evident from the data that the pineapple plant is susceptible to aphis transmittal of *C. nudiflora* mosaic.

The fact that all three aphis species reproduced freely on the very small seedlings is evidence that if the plant tissue is soft enough to permit feeding, the plant is a favorable host.

The difficulty of transmittal to field grown plants is probably due to the inability of the aphis to penetrate the harder, tougher tissue of field grown plants.

This factor is probably a protective one under field conditions and its operation calls attention to a fact of considerable importance, namely, that a plant may be highly susceptible to a virus but so unfavorable a host for a specific vector that natural infection is rare.

It is true that symptoms of *C. nudiflora* mosaic (Pl. I, Fig. 1) on pineapple are so similar to those of yellow spot, especially in the later stages, that the first-named may easily be confused with yellow spot in the field, but until the virus of *C. nudiflora* can be recovered from field cases of diseased pineapple plants it must be assumed that the virus does not occur in pineapple under field conditions.

SUMMARY

Three aphis species, *Aphis gossypii*, *Myzus persicae* and *Macrosiphum solanifolii* have been shown to transmit the virus of *Commelina nudiflora* mosaic to pineapple plants.

Percentage of infection obtained under laboratory conditions decreases as the pineapple seedlings used become older and the tissues more resistant to penetration by aphis.

The disease is not known to exist in commercial pineapple fields.

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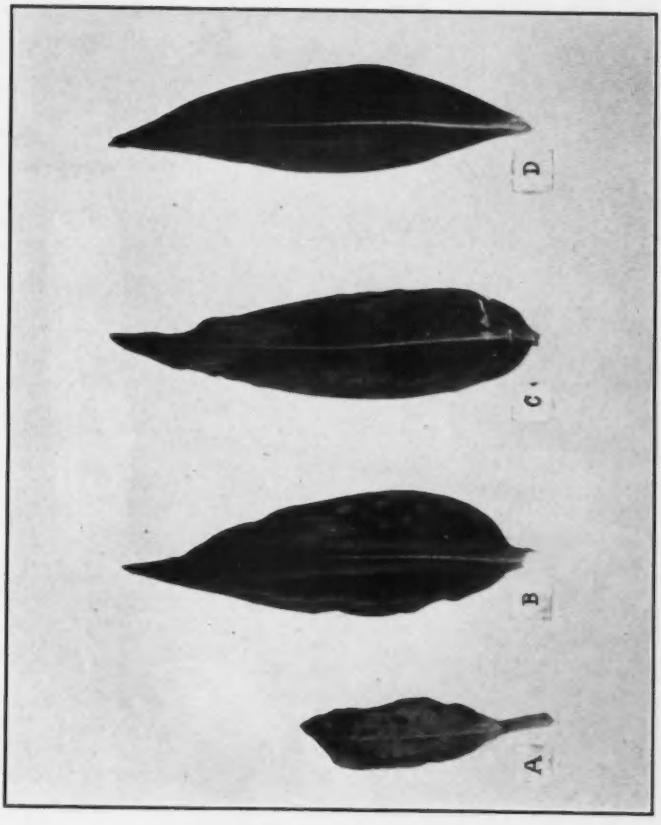
EXPLANATION OF PLATES

PLATE I

Fig. 1. A, B and C, Diseased leaves of *Commelina nudiflora* L. D, Healthy leaf of *Commelina nudiflora* L.

PLATE II

Fig. 2. E, F and G, Diseased young pineapple plants. E, *Commelina nudiflora* mosaic transmitted by *Macrosiphum solanifolii* (Ashm.), showing a systemic streak symptom. F, *Commelina nudiflora* mosaic transmitted by *Aphis gossypii*. Initial ringspot with secondary zonations. G, *Commelina nudiflora* mosaic transmitted by *Aphis gossypii*. The initial symptom in this case was the series of inner areas, the zonation developing later as a secondary symptom.


D
C
B
A

NEW HYMENOPTEROUS PARASITES OF ANTS (CHALCIDOIDEA: EUCHARIDAE)

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Orasema sixaolae new species

FEMALE. (Fig. 15.) Length 1.7 mm. Head (Fig. 16) in front view subtriangular about as wide as long; in dorsal view, one and one-third times the width of the thorax. Antennae ten-segmented; scape one-fifth the entire length and extending two-thirds the distance to the top of the head; inserted in a wide longitudinal furrow. Flagellum somewhat clavate; segments very short, except the terminal, which is three times as long as the average. Right mandible with two rather stout teeth on the medial border, the left with only one; apices slender, curved, acute. Eyes oval, their length one-third the length of the head and one and one-third the malar space. Ocelli in a triangle; posterior pair about the same distance from the eyes as from the front ocellus but twice as far from each other. Thorax one-third the total length; width five-eighths and height two-thirds its own length. Mesoscutum trilobed, the lobes convex. Scutellum simple. Mesepisterna shallowly punctate in the middle. Metepisterna smooth. Legs very slender. Propodeum steeply sloping. Wings with a submarginal vein; forewings also with a postmarginal and a stump of a stigmal vein. Stigma very feebly developed. Abdomen one-half the total length. Petiole very slender, subcylindrical, five and one-half times as long as wide, and at its attachment to the gaster abruptly enlarged ventrally. Gaster slightly compressed, subcircular in side view, its width three-fourths its length. Six dorsal and five ventral segments visible. Ovipositor (Fig. 19) short, thick, acute, with a dorsal row of eight transverse, blunt ridges towards the apex; sheaths thickened in the middle, curved, very acute. Head with punctations which are deeper on the vertex. Region in front of eyes smooth except along the shallow median furrow. Genae and clypeus smooth. Pronotum unsculptured. Praescutum deeply and coarsely punctate; lateral lobes of the mesoscutum glabrous except for some erratic lines near the mid-dorsal suture. Scutellum with the apex subglabrous, the remainder irregularly striated; bounded posteriorly by a ridge. Metanotum very short. Propodeum with a coarsely punctate, mid-dorsal, longitudinal ridge and lateral smooth areas. Petiole irregularly roughened. Gaster shiny. Coxae faintly striated. Mesepisterna variously punctate; metepisterna smooth. Hairs absent, with the following exceptions: four long hairs on the anterior margin of the clypeus; a few minute hairs on the genitalia; pubescence on the flagellum (except the first joint), the tarsi, and the wings. Head, thorax, and petiole fuscopiceous to piceous with a reddish metallic lustre; gaster uniformly ferrugineous; mandibles, antennae, and femora fuscous; eyes, ocelli, tarsi, tibiae, and genitalia fulvous.

Description based on two females from a nest of *Solenopsis* (*Diplorhoptrum*) *tenuis* Mayr, in dead twig, Sixaola River, Province of Limón, Costa Rica, VII–29–1924. Collected by G. C. Wheeler. Host identified by Dr. W. S. Creighton. Types in the authors' collection.

YOUNG LARVA. (Figs. 1, 2.) The very young larva or planidium (length 0.12 mm.) has ten to twelve closely applied segments visible. The body is subellipsoidal, the posterior fourth being somewhat narrowed and more acute than the anterior. On the ventral surface the posterior margin of each segment from the fourth to the eighth inclusive, bears a pair of short, obtuse, tooth-like projections. Each thoracic segment has a pair of dorsal hairs, and the terminal segment two stout bristles. The head (Fig. 7) is ovoidal, its length one and one-fourth times the width. The short metopic suture impresses the center of the occipital border. There is a pair of papillae on the frontal region, a more lateral pair on the temporal region, and four smaller structures, probably also papillae, at the attachment of the labrum. The mandibles are simple, curved, and acute. The distal border of the labrum has a row of nine papillae; when the mouth is distended, this row becomes projected forward beyond the other mouth parts. The center of the anterior (?) labial surface bears four papillae on a square area which is connected with the distal border by a furrow. On each side of this furrow, two pairs of relatively large papillae lie along the distal border.

A somewhat older larva (length 0.2 mm.) might also be called a planidium (Fig. 4), but its twelve segments are distended so that the length is one and two-thirds that of the young planidium. The first and second dorsal sclerites are in contact as are also the eighth to twelfth inclusive. The intermediate sclerites are more or less widely separated and the body is considerably swollen ventrally. The first three dorsal plates bear each a pair of hairs. The first one also has a disc-like structure visible laterally, which may be a hair-base. The anal bristles have probably been broken off, since structures were seen which might be their stumps. The ventral pairs of tooth-like projections on the fourth to eighth segments, the hairs, and the characters of the head are like those of the undistended planidium.

Orasema costaricensis new species

FEMALE. (Fig. 20.) Length 2.7 mm. Head (Fig. 17) in front subtriangular, about as wide as long. Scape extending four-fifths the distance to the top of the head. Eyes about one-half the length of the head and one and one-third the malar space. Ocelli in a triangle; distance between the posterior pair about three-fourths that from the eyes, but twice that from the anterior ocellus. Maxillary palpi three-, labial two-jointed (Fig. 21). Head one and one-fourth the width of the thorax above. Thorax about one-third the entire length, height and width each two-thirds its own length. Forewings with submarginal, short postmarginal, and stump of stigmal veins. Abdomen one-half the total length. Petiole six times as long as wide, not enlarged at the posterior end. Gaster slightly compressed, almost as high as long; dorsal

width five-eighths the length; height one and one-third times the width. Ovipositor (Fig. 18) slender with a dorsal row of nine transverse blunt ridges; sheaths slender, tips curved, acute, with six ventral teeth near apex. Head (including genae) very coarsely punctate; striated behind, the striations following the contours. Scutum and scutellum roughly punctate dorsally. The rows of dorsal pits on the lateral lobes of the mesoscutum run in two directions separated by a fine transverse ridge; the anterior rows are transverse, the posterior longitudinal. Mesepisterna punctate all over, and metepisterna faintly punctate. Four hairs on the anterior margin of the clypeus; a few small hairs on the genitalia. Flagella (except the first joint), apex of hind tibiae, tarsi and wings pubescent. Head and thorax piceous with a greenish lustre. Abdomen ferrugineous, darker above. Flagella, coxae, and front femora fuscous; rest of legs, scapes, ocelli, eyes, and mandibles (except brown tips of teeth) fulvous. Wings iridescent.

Description based on one female and four mature pupae from a nest of *Pheidole flavens* Roger var. in rotten log, Zent, Costa Rica, VI–24–1924. Collected by G. C. Wheeler. Host identified by Dr. W. M. Wheeler. Types in the authors' collection.

YOUNG LARVA. (Fig. 3.) The smallest planidium (length 0.17 mm.) in our material is already somewhat inflated. Sclerites one to two and five to twelve are still in contact and the body back to the seventh segment is distended below. A much larger larva (length 0.48 mm.), almost three times as long and as wide as the former (Figs. 5, 6), has all segments up to the eighth so widely separated that the sclerites are scarcely recognizable as such. These sclerites and the head are of the same size as those on the less distended planidium; this would suggest that the growth of the planidium is made possible by the spreading of the softer membranes rather than by ecdysis. Both larvae have the same integumental characters. Pro-, meso-, and metathoracic segments bearing each a pair of single, slender hairs on the dorsal surface; the anal segment also bearing a single pair, usually broken off in the much distended form. One or two pairs of discs (sensory?) on the anterior margin of the mesothoracic plate. Pairs of tooth-like projections present on the ventral surface of the fourth to eighth segments. Head (Fig. 8) somewhat elongate, oval, its length one and one-fourth times its breadth, with a very short metopic suture; posterior angles of the head rounded. Four pairs of sensory discs on the front, the two lateral pairs larger, each with a distinct peg-like protuberance. The heavily chitinized plate of the head widely separated mid-ventrally. Mandibles slender, falcate, acute, concealed under the labrum and attached to thickly chitinized triangles. In the center of the labium a short, transverse, arcuate line (opening of sericteries?); the ends of this line connected by fainter lines with a elliptical elevation at the apex of the labium; two paired structures, probably papillae (the dorsal one bearing a minute spinule), at either end of this elevation.

MATURE LARVA. (Figs. 11, 12.) This stage (length 1.77–2.15 mm.) is composed of eleven segments in addition to the head. The body is

elongate, moderately stout and subcylindrical with the ends rounded; the head and anal segment are ventral. There are two dorso-lateral rows of nine pustulate protuberances (suggesting in shape immature mushrooms), one row immediately dorsal to each row of spiracles. In addition, the meso- and metathorax bear each a pustule below the spiracle on either side. The first abdominal segment is slightly depressed and somewhat expanded ventrally. A mid-dorsal furrow divides the anterior half of the prothorax into two lateral lobes. On the side of each lobe projects a simple, low, rounded excrescence. The small head (Fig. 9) is very short, the height being three times the length; the width is one and one-third the height. On the front there is a median longitudinal depression separating a pair of subcircular convexities. A pair of minute sensory discs are located near the center of the depression; between this pair and the mouth parts are five more. Labrum short and broad; mandibles small, acute, curved outwards, too short to meet; labium transversely elliptical, with a small notch in the center of the distal border. A few minute discs (sensillae?) on each lateral surface of meso- and metathorax. Integument of prothorax, intersegmental regions, and anal segment furnished with small obtuse spinules, varying in size. Nine pairs of spiracles, each on a small elevation.

At this stage, the parasite has become separated from its host. Whether it was still feeding could not be ascertained. If it eats at all, it is probably ectoparasitic in contrast with the planidium which is endoparasitic.[1]

SEMIPUPA. (Fig. 13.) The semipupa (length 1.8 mm.) is similar to the mature larva except that segments three to five (inclusive) are enlarged so as to form a mid-ventral swelling, which is corrugated by the impressed intersegmental furrows; the corrugations terminate abruptly in the ventrolateral region.

PUPA. (Fig. 14.) The pupa (length 2.4 mm.) has a mid-dorsal longitudinal row of three pustulate tubercles, formed from the pupal membrane, on the posterior thoracic and petiolar regions. They are globular in shape and abruptly constricted at their attachment. The intersegmental folds are prominent on the gastric dorsum and sides. The anterior fold is much the largest, its lateral termini are strongly produced, and its mid-dorsum forms a subglobular knob. The other folds become progressively smaller and lack the lateral dilations. Other smaller and simpler protuberances are present: one in the clypeal region, another above the antennal insertions, three over the ocelli, one on the pronotum, and several near the genitalia.

DISCUSSION

ADULTS. *Orasema sixaolae* is smaller and more finely punctate than *O. costaricensis*. The subclavate flagellum has shorter

[1]Wheeler (1907, p. 9) says of *O. viridis*, "As soon as the full grown *Orasema* has been separated from its prey, it begins to pupate." Perhaps in our species also it starts to change immediately without further feeding.

segments (except the apical). The genae are smooth instead of punctate; the clypeal hairs longer. The propodeum is sculptured into a mid-dorsal, longitudinal, coarsely punctate ridge with lateral smooth areas while *O. costaricensis* is finely punctate. The apex of the petiole of *O. sixaolae* is enlarged ventrally. Although the abdomen is ferrugineous in both, the thorax is differently colored: *O. costaricensis* is piceous with a greenish lustre; *O. sixaolae* is more fusco-piceous with a reddish lustre. In both species the thorax is one-third the entire length, the abdomen one-half; antennae ten-segmented; maxillary palpi three-jointed, labial two; mesoscutum trilobed; scutellum without projections; propodeum steeply sloping; petioles slender, gaster shiny, subcircular and slightly compressed; fore wings with submarginal, short post marginal and feeble stigmal veins.

Some of the above characters may be generic, but it is impossible to decide until Girault's unpublished monograph is available or until more complete descriptions are published. Moreover, the paucity of specimens makes it difficult to generalize about specific characters.

PLANIDIA. All the known first-stage eucharid larvae are planidia and may be characterized as follows: obovoid; head and dorsal plates heavily sclerotized, the latter often meeting below; hairs or short teeth or both on some segments; anal segment often with a pair of bristles; mouth usually distensible; mandibles simple, comma-shaped, with the apex slender and acute. In addition to *Orasema sixaolae* and *O. costaricensis* (*vide supra*), planidia of the following species have been reported in the literature: *Orasema viridis* Ashmead (Wheeler, 1907, p. 7, and Smith, 1912, p. 59), *Psilogaster fasciiventris* Brues (1919, p. 15), *Schizaspidia tenuicornis* Ashmead (Clausen, 1923, p. 199), *S. manipurensis* Clausen (1928, p. 84), and *Stilbula cynipiformis* Rossi (Parker and Thompson, 1925, p. 393).

OLDER PLANIDIA. Since the enlarged planidium of *O. sixaolae* differs from its early stage only in length and distention, we should expect the same to be true of *O. costaricensis*, although no unswollen planidia were found. The similarly distended planidia of these two species are comparable in shape, ventral teeth and hairs but the head and mouth parts are different.

Since we have been unable to find any fundamental external differences between planidia of various sizes nor any change in the size of the head and dorsal plates, we consider it highly probable that no ecdysis occurs during the swelling of the

planidium. Wheeler (1907, p. 8) found distended planidia of *Orasema viridis;* Brues (1919, p. 16) of *Psilogaster fasciiventris;* Clausen (1923, p. 216) of *Schizaspidia tenuicornis;* and Parker and Thompson (1925, p. 393) of *Stilbula cynipiformis.* No one has witnessed a molt, but Brues (p. 15) found a cast skin of an engorged planidium attached to the "mature larva" of *P. fasciiventris,* indicating that in his case there were no other stages in between. Wheeler figured (Pl. II, Fig. 16) an older larva without the dorsal bands so characteristic of the enlarged planidium. He thought (p. 8) that the fact that all traces of the dark bands had disappeared was probably due to "the intervention of an ecdysis." Clausen (1923, p. 200) also found a second stage larva without dorsal bands in *Schizaspidia tenuicornis.* His third stage larva is quite extraordinary; there is a unique suctorial mouth but no mandibles.

MATURE LARVA. Wheeler (1907, p. 9) says that the larva of *O. viridis* (without dorsal bands) referred to above molts to "a short thick-set semipupa, slightly constricted just in front of the middle of its body. Another ecdysis seems to follow almost at once leaving the semipupa covered with a peculiar envelope studded with large blisters, or pustules." The pustules are "arranged segmentally in regular rows along each side of the body but are absent in the middorsal and midventral lines." Judging from Wheeler's figures (Pl. II, Figs. 18, 19), these pustules are more numerous than those of *O. costaricensis.* He is unable to assign them any function. Reichensperger (1913, p. 12) considers them "eine Art von Exsudatknospen" because the host workers lick and protect the parasitic larvae. But host ants often lick other parasites which apparently have no special exudate organs as if they were their own brood. The full-grown larva of *Psilogaster fasciiventris* has a large vesicular swelling at the anterior end (Brues, 1919, p. 16) which may be comparable to the above mentioned pustules.

PUPA. The pupae of Eucharidae also have various swellings which are sometimes very similar in appearance to the larval pustules. In 1890 (p. IX) Forel mentions the "curieuses nymphes . . . couvertes d'aspérités et de boursoufflures" of *Eucharis myrmeciae* Cameron. Reichensperger (1913, Pl. 6, Fig. 12) figures a pupa of *Psilogaster fraudulentus* Reich. with dorsal tubercles like those of the pupa of *O. costaricensis,* with pronounced abdominal folds, and with smaller subglobular projections on the head and sides of the thorax. He says (p. 213),

"Der Hinterleib ist mit einer Anzahl wallförmiger Erhebungen umgürtet, die seitlich und oben in der Mittellinie Verdickungen aufweisen. Ferner liegen drei kuglige stark vortretende Knötchen zwischen Metathorax und Abdomen über dem Pedicellus; endlich besitzt die Vorderseite des Kopfes oben mehrere kuglige Vorsprünge . . ." Wheeler (1907, p. 9) describes the pupa of *O. viridis* as "enclosed in a thick membrane (Pl. II, Fig. 22) which, in the intersegmental regions of the abdomen, is thrown into prominent transverse welts," but it lacks the tubercles or pustules, which he found on the mature pupa of *O. coloradensis* Ashmead (p. 13, Pl. IV, Figs. 53, 54). On the latter they are even more abundant than on *O. costaricensis*. *Psilogaster fasciiventris* (Brues, 1919, p. 17) has the whole body beset "with vesicular swellings. The mesonotum bears a small rounded tubercle at each side of the anterior edge, an acute one near each tegula and a widely separated pair of sub-acute ones on the disc before the scutellum. . . There are no tubercles above the propodeum and petiole." In a recent paper (1934, p. 205) on Australian eucharids, Brues finds that the pupa of *Tricoryna chalcoponerae* Brues "shows no striking characteristics except that the margins of the abdominal tergites are distinctly raised and carinate, the edge of the second tergite projecting as a distinct, sharp tooth on each side not far from the median line." There is therefore considerable difference in these tubercles both between and within genera.

Brues (1919, p. 19) believes that these pustules "were originally either secretory or excretory organs, or those assisting in some way in the process of ecydsis." He also mentions (p. 20) Dr. W. M. Wheeler's suggestion that they might be of assistance in eliminating large amounts of water during growth.

Number of Molts. It is impossible at present to state the number of molts in the Eucharidae. For *Orasema viridis*, Wheeler (1907) records two larval stages, two semi-pupal, and one pupal. For *Schizaspidia tenuicornis*, Clausen (1923) reports three larval stages and one pupal. In *O. costaricensis*, there are probably three larval stages, a semi-pupal and a pupal. These available data would suggest four or five stages between egg and adult.

RELATIONS TO HOSTS

Entrance Holes. The first stage larva of *O. sixaolae* penetrates the host by way of a simple, unthickened, rounded open-

ing cut through the integument. From this opening a few (usually four) posterior segments of the planidium protrude. As the parasite distends, the periphery of this hole becomes thickened and forms an indistinct collar, projecting inward; the opening, however, maintains the original diameter (about 0.045 mm.). The depth of the collar varies slightly, the larger the parasite, the deeper the collar. *O. costaricensis* (Fig. 10) causes the formation of a similar aperture.

Position of Parasites on Hosts. Twelve host larvae of *Solenopsis tenuis*, ranging in length from 0.7 to 1.6 mm., i. e., from very young to mature, were infested with eighteen small endoparasitic planidia of *O. sixaolae*. Eight had one parasite each, two had two each, and two had three each. Of the single infestations four were on the anterior half of the host larva and dorsal in position; four were near the middle, three of these anterior and ventral, while one was posterior and dorsal. Of the double infestations: in one case both parasites were dorsal and on the posterior half; in the second case one was anterior and dorsal and the other posterior and ventral. Of the triple infestations: in one case all were dorsal, two near the middle and one on the posterior half; in the other case, of the two near the middle, one was lateral, the other was dorsal, and the third was anterior and dorsal.

Seven host larvae of *Pheidole flavens* var., ranging in length from 1.9 to 2.2 mm., were infested with eight more or less distended planidia of *O. costaricensis*. Four infestations (including a double one) were anterior and dorsal, two posterior and ventral, and one in the extreme posterior end.[2]

None of our mature *Orasema* larvae was attached to a host larva and no parasite at any stage was found on a host pupa.

The actual process of parasitization by Eucharidae was discovered by Clausen. He found that the female of *Schizaspidia tenuicornis* (1923, p. 195) and also *S. manipurensis* 1928, p. 85) laid their eggs in buds of trees or shrubs; the newly hatched planidia attached themselves to passing workers of *Camponotus herculeanus japonicus* Mayr, and were thus carried to the nest where they transferred themselves to the brood.

[2]Dodd (1906, p. 123) states that *Rhipipallus affinis* Bingham may produce "several sometimes from one cocoon" of *Odontomachus ruficeps* subsp. *coriaria* Mayr.

HOST RECORDS OF EUCHARIDAE[3]

Chalcura sp. Host: *Formica rufa* L. Wasmann, (1894) p. 168. "Prag (Polak)."

Chalcuroides versicolor Girault. Host: *Myrmecia* sp. Girault, (1915) p. 236. Townsville, Queensland, Australia.

Epimetagea purpurea Girault. Host: "reared from ants." Girault, (1915) p. 226. Townsville, Queensland, Australia.

Eucharis adscendens Fabr. Host: *Messor barbarus* L. Fahringer and Tölg, (1912) p. 249. Fahringer, (1922) p. 42. Ruschka, (1924) p. 84. Southern Europe, warmer regions of middle and western Europe.

Eucharis bedeli Cameron. Hosts: *Cataglyphis bicolor* Fabr. and *Fornica rufa* L. Bedel, (1895) p. XXXV. Djebel Edough, Algeria.

Eucharis myrmeciae Forel. Host: *Myrmecia forficata* Fabr. Forel, (1890) p. IX. Janet, (1897) p. 52. South Australia, East India.

Eucharis punctata Förster. Host: *Messor barbarus semirufus* var. *concolor* Emery. Fahringer, (1922) p. 42. Southern Europe.

Eucharomorpha wheeleri Brues. Host: *Pheidole proxima* Mayr. Brues, (1934) p. 203. Wentworth Falls (alt. 2800 ft.), New South Wales.

Isomeralia coronata Westwood. Host: *Ectatomma tuberculatum* Olivier. Cook, (1905) p. 15, footnote. Wheeler, W. M., (1907) p. 17, Pl. IV, Fig. 58, 59. Brazil, Bahia and Amazons, South America.

Kapala cuprea Cameron. Host: *Pachycondyla crassinoda* Latr. Myers, (1931) p. 276. Trinidad.

Kapala floridana Ashmead. Host: *Pogonomyrmex badius* Latr. Wheeler, W. M., (1907) p. 17, Pl. IV, Figs. 56–57. Florida.

Orasema coloradensis Ashmead. Hosts: *Pheidole vinelandica* Forel and *Solenopsis molesta* var. *validiuscula* Emery. Wheeler, W. M., (1907) p. 12, Pl. I, Fig. 12; Pl. IV, Fig. 53; Pl. V, Fig. 68. Colorado.

Orasema costaricensis G. and E. Wheeler. Host: *Pheidole flavens* Roger. Wheeler, G. and E., (in this paper). Zent, Costa Rica.

Orasema minutissima Howard. Host: *Wasmannia auropunctata* Roger. Mann, (1918) p. 106. St. Vincent and Cuba.

Orasema pheidolophaga Girault. Host: *Pheidole* sp. Girault, (1915) p. 230. Geelong, Victoria, Australia.

Orasema sixaolae Wheeler, G. and E. Host: *Solenopsis* (*Diplorhoptrum*) *tenuis* Mayr. Wheeler, G. and E., (in this paper). Sixaolae River, Province of Limón, Costa Rica.

Orasema tolteca Mann. Host: *Pheidole vasliti* var. *acolhua* Wheeler. Mann, (1914) p. 184. State of Hidalgo, Mexico.

Orasema viridis Ashmead. Hosts: *Pheidole kingi* subsp. *instabilis* Emery. Wheeler, W. M,. (1907) p. 2, Pl. I, Figs. 10, 11; Pl. II, Figs. 13–23, 30–35. *Pheidole sciophila* Wheeler, W. M., *ibid.*: p. 12. Texas.

Oresema wheeleri Ashmead. Host: *Pheidole ceres* Wheeler, W. M., (1907) p. 14. Fort Davis, Texas.

Pseudochalcura gibbosa Provancher. Host: *Camponotus herculeanus* var. *noveboracensis* Fitch. Wheeler, W. M., (1907) p. 16, Pl. II, Fig. 29; Pl. IV, Fig. 55. Michigan.

[3]All known hosts of the Eucharidae are ants.

Pseudometagea schwarzi Ashmead. Host: "taken in an ant's nest." Wheeler, W. M., (1907) p. 17. Washington, D. C., and Maryland.

Psilogaster fasciiventris Brues. Host: *Myrmecia gulosa* Fabr. Brues, (1919) p. 14, Pl. I, Fig. 2. Hornsby, New South Wales.

Psilogaster fraudulentus Reichensperger. Host: *Pheidole megacephala* Fabr. Reichensperger, (1913) p. 211, 2 Figs. Abyssinia.

Rhipipallus affinis Bingham. Host: *Odontomachus ruficeps* subsp. *coriaria* Mayr. Dodd, (1906) p. 123. Townsville, Queensland, Australia.

Schizaspidia calomyrmecis Brues. Host: *Calomyrmex purpureus* Mayr. Brues, (1934) p. 207. Meekatharra, West Australia.

Schizaspidia doddi Bingham. Host: *Camponotus* sp. Dodd, (1906) p. 123. Townsville, Queensland, Australia.

Schizaspidia polyrhachicida G. and E. Wheeler. Host: *Polyrhachis* (*Myrmhopla*) *dives* F. Smith. Wheeler, G. and E., (1924) p. 51. Philippine Islands.

Schizaspidia tenuicornis Ashmead. Host: *Camponotus herculeanus* subsp. *japonicus* Mayr. Clausen, (1923) p. 195. Japan.

Stibula cynipiformis Rossi. Hosts: *Camponotus*[4] sp. Parker and Thompson, (1925) p. 393. *Camponotus marginatus* Latr. Fahringer and Tölg, (1912) p. 250. *Camponotus maculatus sanctus* Forel. Fahringer, (1922) p. 42. *Camponotus aethiops* (Latr.) Parker, (1932) p. 3, 3 Figs. Warmer regions of central and southern Europe, Asia Minor, northern Africa.

Tricoryna chalcoponerae Brues. Host: *Chalcoponera metallica* F. Smith. Brues, (1934) p. 204. Mt. Kosciusko (alt. 3000 ft.), New South Wales.

Tricoryna ectatommae Girault. Host: *Ectatomma* sp. Girault, (1915) p. 228. Melbourne, Victoria, Australia.

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[4]The classification of these *Camponoti* are still in an unsettled state, and there may be some synonymy here. According to Emery (1925, p. 77, footnote 1) the forms of *Camponotus* "sous le nom d'ensemble collectif de *C. maculatus* . . . de sorte que cet ensemble est devenue peu à peu un véritable chaos." He considers C. *marginatus* Mayr a synonym of *C. aethiops* var. *marginatus* (Latr.) and *C. maculatus sanctus* Forel of *C. compressus* subsp. *sanctus* Forel.

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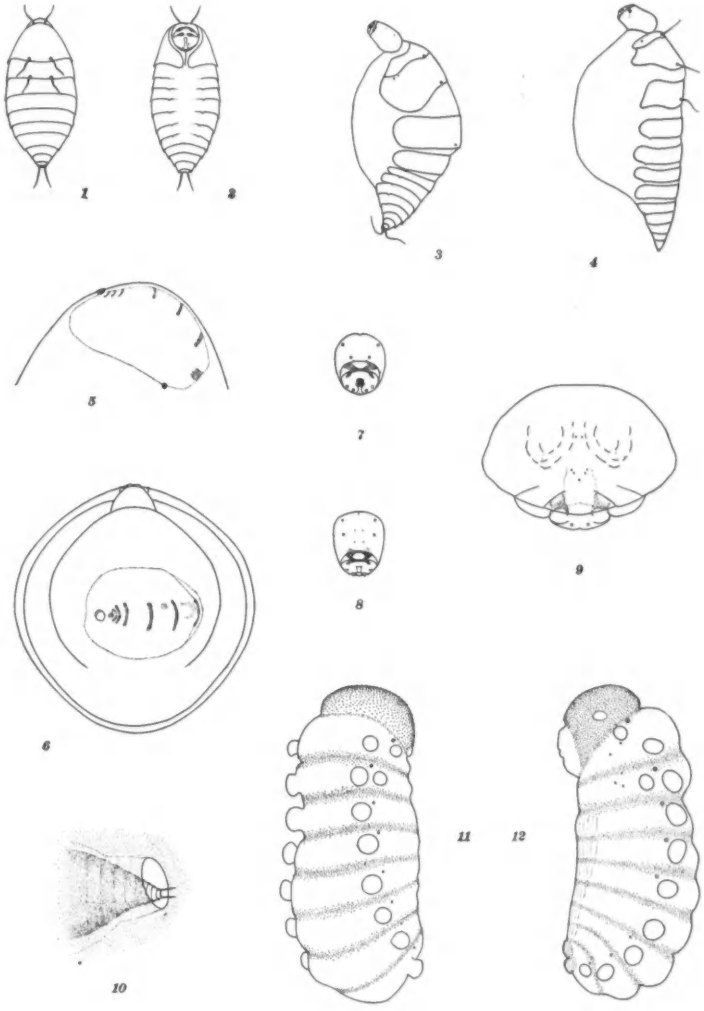
EXPLANATION OF PLATES

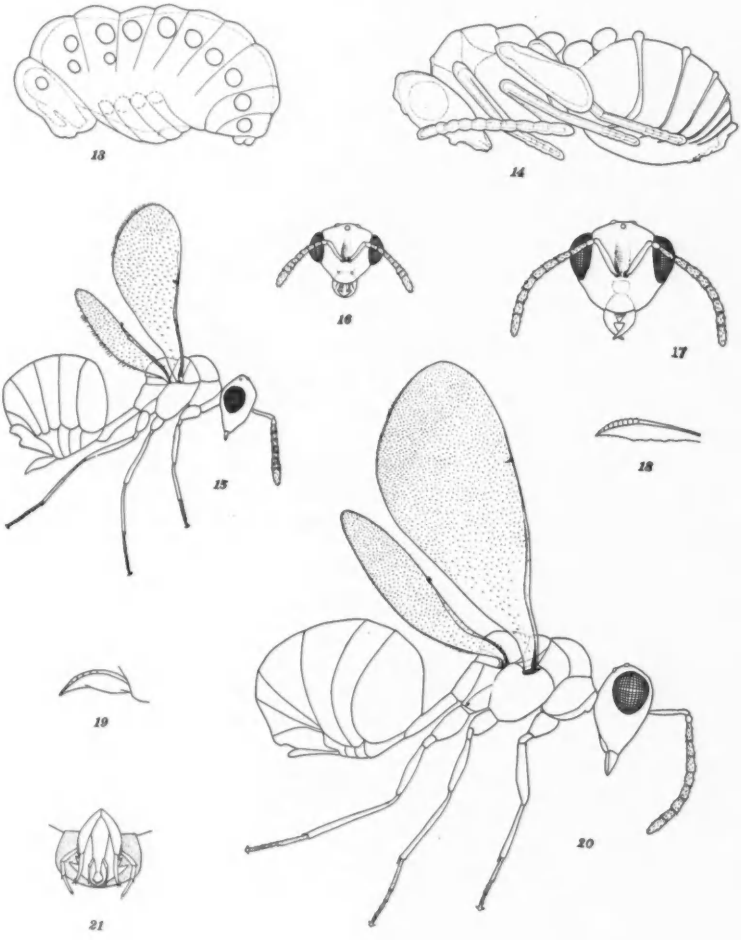
Plate I

Fig. 1. Planidium of *Orasema sixaolae*, dorsal view. ×185.
Fig. 2. Planidium of *O. sixaolae*, ventral view. ×185.
Fig. 3. Distended planidium of *Orasema costaricensis*, side view. ×185.
Fig. 4. Distended planidium of *O. sixaolae*, side view. ×185.
Fig. 5. Much distended planidium of *O. costaricensis* inside the prothorax of the host larva, and its entrance hole. ×45.
Fig. 6. Host larva in anterior view showing the much distended planidium of *O. costaricensis* (posterior-dorsal aspect), and its entrance hole. ×45.
Fig. 7. Head of young planidium of *O. sixaolae*, antero-ventral view with the mouth retracted. ×185.
Fig. 8. Head of younger planidium of *O. costaricensis*, anterior view. ×185.
Fig. 9. Head of mature larva of *O. costaricensis*, anterior view. ×93.
Fig. 10. Entrance hole in host's integument with posterior end of planidium of *O. costaricensis in situ*. ×185.
Fig. 11. Mature larva of *O. costaricensis* in dorso-lateral view. ×22.
Fig. 12. Same mature larva in side view. ×22.

Plate II

Fig. 13. Semipupa of *Orasema costaricensis* in side view (spinules not shown). ×22.
Fig. 14. Pupa of *O. costaricensis* in side view. ×22.
Fig. 15. Adult of *O. sixaolae*, ♀, side view. ×22.
Fig. 16. Head of *O. sixaolae* in anterior view. ×22.
Fig. 17. Head of *O. costaricensis* in anterior view. ×22.
Fig. 18. Ovipositor of *O. costaricensis* in side view. ×48.
Fig. 19. Ovipositor of *O. sixaolae* in side view. ×48.
Fig. 20. Adult of *O. costaricensis*, ♀, in side view. ×22.
Fig. 21. Adult mouth parts of *O. costaricensis* in ventral view. ×48.

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PROCEEDINGS OF THE THIRTY-FIRST ANNUAL MEETING

Atlantic City, New Jersey, December 28-30, 1936

The Entomological Society of America held its Thirty-first Annual Meeting on Monday, Tuesday and Wednesday.

A joint symposium on the subject "Insects Affecting Man" was held on Monday afternoon. The symposium was sponsored by the Entomological Society of America and the American Association of Economic Entomologists, DR. L. O. HOWARD, pioneer in Medical Entomology and former chief of the Bureau of Entomology, presided.

The Annual Public Address was given by DR. EDITH M. PATCH of the University of Maine. Her subject was "Without Benefit of Insects." In this address Miss Patch discussed the wholesale slaughter of insect life that has resulted from the attempts to control injurious insects, its effect on the production of various crops which require insects for the pollination of their flowers, and the possibility that some time in the future entomologists will be as much or more concerned with the conservation and preservation of beneficial insect life as they now are with the destruction of injurious insects. The program of papers presented at the three days meeting follows:

Opening Session, Monday Morning, December 28

The Society was called to order at 9:30 A. M. by PRESIDENT H. B. HUNGERFORD in the BENJAMIN WEST ROOM of HADDON HALL. The following papers were presented:

1. The Effect of Fertilization on the Ovipositional Behavior and the Development of Certain Hymenoptera. (15 min.) (Lantern.) STANLEY E. FLANDERS, Citrus Experiment Station, Riverside, Calif.
2. Some Parallel Modifications in Hymenoptera Parasitic on Wood-Boring Insects, with Particular Reference to the Ichneumonidae. (15 min.) (Lantern.) HENRY K. TOWNES, Cornell University, Ithaca, New York.
3. The Origin and Nature of the Stylet Track of Aphids. (10 to 15 min.) (Lantern.) A. A. GRANOVSKY, University of Minnesota, St. Paul, Minn.
4. The Origin and Modifications of Half-Spindle Fibers in *Arixenia jacobsoni* Burr. (By Title.) HAROLD R. HAGAN AND J. W. JAILER, College of the City of New York, New York City.
5. The Role of the Egg Shell in the Respiration of the Larva of *Oöencyrtus johnsoni* (Howard). (15 min.) (Lantern.) JOHN D. MAPLE, Citrus Experiment Station, Riverside, Calif.
6. The Effect of Temperature upon the Oxygen Consumption of the Cluster Fly, *Pollenia rudis* Fabr. (15 min.) (Lantern.) VIRGIL N. ARGO, College of the City of New York, New York City.
7. The Significance of Trichopterous Larvae in Studying Respiration of Small Aquatic Invertebrate Animals with Slow Blood Circulation. (10 min.) MISS MARGERY GREENE, University of Maine, Orono, Maine, and LORUS J. MILNE, Southwestern University, Georgetown, Texas. (Introduced by C. T. Brues.)
8. Notes on the Genus *Tenagobia* with a Description of a New Species (Corixidae, Hemiptera). (By Title.) HOWARD O. DEAY, Purdue University, Lafayette, Ind.
9. The Genus *Scaphoideus* in North America. (10 min.) (Lantern.) DWIGHT M. DELONG AND LAURENCE BEERY, Ohio State University, Columbus, Ohio.

10. The Influence of a Pure Carbohydrate Diet on Newly Emerged Honeybees. (5 min.) MYKOLA H. HAYDAK, University of Minnesota, St. Paul, Minn.
11. Cave Hibernation of Mosquitoes. (10 to 15 min.) (Lantern.) J. D. IVES, Jefferson City, Tenn.

The following committees were appointed by President Hungerford:

Nominating Committee—WM. A. RILEY, Chairman; EDNA MOSHER, A. F. SATTERTHWAIT.

Resolutions Committee—O. A. JOHANNSEN, Chairman; R. E. Snodgrass, WALTER H. WELLHOUSE.

Auditing Committee—A. A. GRANOVSKY, Chairman; RAYMOND C. OSBURN; HOWARD DEAY.

The Society then adjourned to meet with the American Association of Economic Entomologists to hear the address of their president, Mr. L. S. MCLAINE.

Second Session, Monday Afternoon, December 28

Joint Session with American Association of Economic Entomologists.

SYMPOSIUM: "INSECTS AFFECTING MAN."

The session was called to order by Dr. L. O. HOWARD at 2:30 P. M. and the following papers were presented:

Mosquitoes and Their Control. T. J. HEADLEE, Rutgers University, New Brunswick, N. J.
Discussion Leader, R. D. GLASGOW, New York State Museum, Albany, N. Y.

Anopheline Mosquitoes and Malaria. L. L. WILLIAMS, JR., U. S. Public Health Service, Washington, D. C.
Discussion Leader, F. C. BISHOPP, Bureau of Entomology and Plant Quarantine, Washington, D. C.

Some Therapeutic Uses of Insects and Their Products. WM. ROBINSON, Bureau of Entomology and Plant Quarantine, Washington, D. C.
Discussion Leader, W. A. RILEY, University of Minnesota, St. Paul, Minn.

Myiasis of Man. W. E. DOVE, Bureau of Entomology and Plant Quarantine, Savannah, Ga.
Discussion Leader, O. R. CAUSEY, Johns Hopkins University, Baltimore, Md.

Ticks in Relation to Man. R. R. PARKER, U. S. Public Health Service, Hamilton, Mont.
Discussion Leader, ROBERT MATHESON, Cornell University, Ithaca, N. Y.

PRESIDENT HUNGERFORD appointed the following fellows to act as alternates for absent members of the Executive Committee, which met at 8:00 P. M., Monday: C. T. BRUES, FRANK E. LUTZ, A. G. RUGGLES.

Third Session, Tuesday Morning, December 29

The Society was called to order at 9:30 A. M. by PRESIDENT HUNGERFORD and the following papers were presented:

12. Structure of the Reproductive System of the Pecan Weevil (Curculionidae). (10 min.) (Lantern.) THEO. L. BISSELL, Experiment, Georgia.
13. The Internal Thoracic Skeleton of Dragonflies. (15 min.) (Lantern.) WILLIAM DUNLAP SARGENT, Westport, Conn.
14. Mechanocardiographic Method of Recording the Insect Heart Beat, with Special Reference to the Effect of Nicotine on the Heart of the Cockroach,

Periplaneta americana L. (10 min.) (Lantern.) J. FRANKLIN YEAGER, Bureau of Entomology and Plant Quarantine, Washington, D. C.

15. Quantitative Injection and Effects of Nicotine in Insects. (15 min.) (Lantern.) N. E. MCINDOO, Bureau of Entomology and Plant Quarantine, Washington, D. C.
16. Effect of Nicotine on Rhythmicities of Isolated Heart Preparations from the Cockroach, *Periplaneta americana* L. and the Southern Armyworm, *Xylomogos eridania* Cram. (15 min.) (Lantern.) J. FRANKLIN YEAGER AND J. B. GAHAN, Bureau of Entomology and Plant Quarantine, Washington, D. C.
17. Specificity of Insecticidal Action. (10 min.) HAROLD H. SHEPARD, University of Minnesota, St Paul, Minn.
18. Certain Features of the Embryology of *Calandra callosa* Olivier, the Southern Corn Billbug. (15 min.) DAVID L. WRAY, Department of Agriculture, Raleigh, N. C.
19. Immunity of Insects to Insect Parasitism. (15 min.) HENRY A. BESS, New Haven, Conn.
20. Systematic Systematics. (15 min.) (Lantern.) Z. P. METCALF, North Carolina State College, Raleigh, N. C.

Fourth Session, Tuesday Afternoon, December 29

Following the call to order at 1:30 P. M. by VICE-PRESIDENT HYSLOP the following papers were given:

21. Rearing Coccinellids, *Hippodamia convergens* Guer. on Frozen Aphids. (10 min.) (Lantern.) G. W. HAUG AND ALVAH PETERSON, Ohio State University, Columbus, Ohio.
22. Nest Parasitism of Hawks. (10 min.) WILLIAM DUNLAP SARGENT, Westport, Conn.
23. The Incidence and Importance of *Cochliomyia americana* C. and P. and other Wound Invading Species for 1936. (10 min.) J. M. BRENNAN, Bureau of Entomology and Plant Quarantine, San Antonio, Texas.
24. Photographing Insects. (15 min.) (Motion pictures.) A. L. MELANDER, College of the City of New York, New York City.
25. Heterogonic Growth in Insects. (15 min.) (Lantern.) J. D. HOOD, University of Rochester, Rochester, N. Y.
26. The Local Relative Abundance of *Scolytus multistriatus* Marsh. in New York with Reference to the Incidence of Dutch Elm Disease. (10 min.) (Lantern.) D. L. COLLINS, Cornell University, Ithaca, N. Y.
27. Life History of the Meal Snout-moth, *Pyralis farinalis* L. in Stored Cereal Products. (By title.) NEWELL E. GOOD, Bureau of Entomology and Plant Quarantine, Manhattan, Kans.
28. Some Observations on *Grylloblatta campodeiformis* Walker. (15 min.) HARLOW B. MILLS AND J. H. PEPPER, Montana State College, Bozeman, Mont.
29. Contribution to Knowledge of *Homaledra sabalella* Chambers. (By title.) JOHN T. CREIGHTON, University of Florida, Gainesville, Fla.
30. Studies on the Pretarsus. (15 min.) (Lantern.) RICHARD T. HOLWAY, South Duxbury, Mass.
31. Experimental Crossing of Subspecies in *Nemobius* (Orthoptera, Gryllidae). (10 min.) (Lantern.) B. B. FULTON, College of Agriculture, Raleigh, N. C.
32. The Adaptive Responses of Taxonomy to a Changing Environment. (15 min.) (Lantern.) C. T. BRUES, Harvard University, Cambridge, Mass.

Fifth Session, Tuesday Evening, December 29

Following the entomologists' dinner, PRESIDENT H. B. HUNGERFORD introduced Dr. EDITH M. PATCH who gave an address on "Without Benefit of Insects."

Sixth Session, Wednesday Morning, December 30

The Society was called to order at 9:30 A. M. by PRESIDENT HUNGERFORD and the following papers were presented:

33. Some Effects of Reduced Pressures on the Life Cycle of *Drosophila*. (12 min.) (Lantern.) LAURENCE A. CARRUTH, New York State Experiment Station, Geneva, N. Y.
34. Determination of the Population Growth of *Microbracon hebetor* Say (Hymenoptera, Braconidae). (15 min.) (Lantern.) MISS NELLIE M. PAYNE, University of Minnesota, St. Paul, Minn.
35. Population Studies of *Formica exsectoides* Forel. (15 min.) (Lantern.) ERNEST N. CORY AND ELIZABETH E. HAVILAND, University of Maryland, College Park, Md.
36. The Role of the Entomologist in Present Day Conservation Programs. (10 min.) J. J. DAVIS, Purdue University, Lafayette, Ind.

The above meetings were attended by about 200, of whom 160 registered with the Secretary.

The following is a report of the Annual Business Meeting which was held Wednesday morning, December 30:

REPORT OF THE SECRETARY

During the year 1936, the following having been duly nominated and recommended were elected members of the Society by mail ballot of the Executive Committee:

EDUARD DEL PONTE, Instituto Bacteriologico, Depto. Nac. de Hygiene, Calle Velez Sarsfield 563, Buenos Aires, Argentina.
HAROLD RODNEY DODGE, Division of Entomology, University Farm, St. Paul, Minnesota.
R. O. MALCOMSON, Box 360, Dept. of Biology, Temple Univ., Philadelphia, Pa.
VIRGIL I. MILES, 1609 Nineteenth St. N. W., Washington, D. C.
JOHN ANDREW MULRENNAN, State Hygienic Laboratory, Austin, Texas.
C. L. RITCHIE, 707 Eastside Ave., Calexico, California.
CHARLES SEEVERS, Dept. of Zoology, Univ. of Chicago, Chicago, Illinois.
RUTH SUMNER. 1114 Twelfth St., Boulder, Colorado.

The Executive Committee, by mail ballot in April, 1936, selected Atlantic City, New Jersey, as the place for the annual meeting in 1936.

DR. T. J. HEADLEE and DR. C. H. HADLEY kindly consented to act as an Arrangements Committee for the Atlantic City meeting.

The Executive Committee, by mail ballot, authorized the Secretary to retain the names of PROFESSOR R. H. PETTIT, PROFESSOR C. P. GILLETTE and PROFESSOR LAWRENCE BRUNER on the membership roll of the Society and to remit their dues annually.

With the approval of the Executive Committee DR. EDITH M. PATCH was invited to give the annual public address of the Society at the Atlantic City meeting.

The Executive Committee met at 8:00 P. M., December 28, in Haddon Hall, Atlantic City, New Jersey, the following officers being present: H. B. HUNGERFORD, J. A. HYSLOP and CLARENCE E. MICKEL. Three other members of the committee were present: ALVAH PETERSON, WM. A. RILEY and W. D. FUNKHOUSER. The following alternates, designated by the President, served in place of absent members of the committee: C. T. BRUES, FRANK E. LUTZ and A. G. RUGGLES.

The following were elected to membership in the Society:

MERLIN W. ALLEN, 232 North 2nd West, Logan, Utah.
VIRGIL N. ARGO, 545 W. 146th St., New York City, N. Y.
DONALD FRED ASHTON, State College Station, Raleigh, N. C.
WALTER C. BAKER, Bur. Ent. and Pl. Quar., 8 Whippany Rd., Morristown, N. J.
VERNON A. BELL, Fernald Hall, Massachusetts State College, Amherst, Mass.
LESLIE BERGREN, University High School, Minneapolis, Minn.
ALBERT WALTER BUZICKY, 489 St. Clair St., St. Paul, Minn.
JAMES FURMAN COOPER, 1100 South St., Key West, Florida.

ARSENIO Y. CORONEL, Agri. College, Laguna Province, Philippine Islands.
HERBERT A. CRANDALL, Dept. of Ent., Ohio State Univ., Columbus, Ohio.
CLIFTON J. DAVIS, 1108 Twenty-fourth St., Ogden, Utah.
KENNETH DEAROLF, 71 Park Rd., Wyomissing Hills, West Lawn, Pa.
BRAYTON EDDY, 52 Taber Ave., Providence, R. I.
ALFRED FENTON, 1104 Second Nat'l. Bank Bldg., Houston, Texas.
FRANK WILBUR FISK, 1369 Cleveland Ave., St. Paul, Minn.
HARRY K. GOUCK, Fernald Hall, Massachusetts State College, Amherst, Mass.
J. LINSLEY GRESSITT, Rm. 112, Agri. Hall, University of California, Berkeley, Calif.
JAMES B. GROSS, 323 E. King St., York, Pa.
OSCAR H. HAMMER, Box 51, Vassar College, N. Y. S. Agri. Exp. Sta., Poughkeepsie, N. Y.
DATUS M. HAMMOND, Dept. of Zool. and Ent., Utah State Agri. College, Logan, Utah.
GALEN A. HINKLE, 630 Whedbee, Ft. Collins, Colorado.
HERBERT S. HURLBUT, Comstock Hall, Cornell Univ., Ithaca, N. Y.
F. B. ISELY, Trinity Univ., Waxahachie, Texas.
DONALD L. JACKMAN, 212 Polk St., Burlington, Iowa.
MING-TAO JEN, Div. of Ent., Univ. Farm, St. Paul, Minn.
WALTER M. KULASH, Fernald Hall, Massachusetts State College, Amherst, Mass.
ALEXANDER W. LEVI, 756 North Sixth East, Logan, Utah.
K. S. LIU, Div. of Ent., Univ. Farm, St. Paul, Minn.
DONALD MACCREARY, Delaware Agri. Exp. Sta., Newark, Delaware.
ALBERT MEAD, 1485 Franklin St., Santa Clara, Calif.
ALBERT MILLER, Comstock Hall, Cornell Univ., Ithaca, N. Y.
GEO. E. NETTLETON 2ND., Fernald Hall, Massachusetts State College, Amherst, Mass.
WILLIAM BERT OWEN, Dept. of Zool., Univ. of Wyoming, Laramie, Wyo.
HARRY D. PRATT, Fernald Hall, Massachusetts State College, Amherst, Mass.
KENNETH DELANEY QUARTERMAN, 1010 Travis Bldg., San Antonio, Texas.
LLOYD EUGENE ROZEBOOM, P. O. Box 5025, Ancon, Canal Zone.
HERBERT F. SCHOOF, State College Station, Raleigh, N. C.
RALPH H. SMITH, Univ. of California, 405 Hilgard Ave., Los Angeles, Calif.
FRED M. SNYDER, Dept. of Econ. Ent., Univ. of Wisconsin, Madison, Wis.
PHILIP C. STONE, Fernald Hall, Massachusetts State College, Amherst, Mass.
M. C. TANNER, 2907 Lincoln Ave., Ogden, Utah.
OSCAR ERNEST TAUBER, Dept. Zool., Iowa State College, Ames, Iowa.
GEORGE A. THOMPSON, JR., Box 125, Kingston, Rhode Island.
RENE MICHEL DU TOIT, Div. of Entomology, Univ. Farm, St. Paul, Minn.
WILLIAM TRAGER, Rockefeller Institute, Princeton, N. J.
R. A. WARDLE, Dept. of Zool., Univ. of Manitoba, Winnipeg, Manitoba, Canada.
R. W. WELLS, P. O. Box 667, Ames, Iowa.
ALLEN S. WEST, JR., 341 Giannini Hall, Univ. of California, Berkeley, Calif.
A. WILKES, Dept. of Biology, Univ. of Toronto, Toronto, Ontario, Canada.

The total number of new members for 1936 is 59.

Upon payment of $50.00 the following were elected to Life Membership: C. W. SABROSKY and G. W. SIMPSON.

The following have resigned during the year: ANDREW O. LARSON, EMIL BOGEN, L. V. COLEMAN, THEODORE H. EATON, JR., F. A. FENTON, ROBERT FOUTS, HENRY FOX, MAURICE C. HALL, F. C. HOTTES, M. NAOMICHI INABA, ARTHUR PAUL JACOT, E. G. KELSHEIMER, G. M. KUTCHKA, CHARLES A. KOFOID, WILLIAM LUNDBECK, CARL O. MOHR, WILLIAM MOORE, L. E. MYERS, R. R. PARKER, EDWIN B. POWERS, PAUL D. SANDERS, ROBERT F. SAZAMA, ERNEST SCHWARZ, CHESTER W. SMITH, J. P. STEAR, A. EDWARD STENE, F. W. URICH, J. MANSON VALENTINE, HACHIRO YUASA.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: K. D. ARBUTHNOT, CHAS. A. BALLOU, JR., E. C. BARR, CHAS. H. BATCHELDER, LYSBETH H. BENKERT, M. T. CHEO, JOHN GRAY, WM. RAU HADEN, LEONE HARDING, L. O. JACKSON, GEO. E. KING, T. P. O. MENZIES, W. R. MILLS, LESLIE ROGERS, C. F. STAHL, K. C. SULLIVAN, GEO. A. THURBER, LOUIS W. ZIEGLER.

The total membership on December 30, 1936, is 952.

The Executive Committee voted to contribute $10.00 toward the expenses of the Biologists' Smoker.

The Executive Committee voted to present to the Society an Amendment to the Constitution and to recommend its adoption at the next annual meeting, as follows: To amend Article IX by substituting the following for Section 1, "This constitution may be altered or amended in the following manner and subject to the following provisions: (1) a copy of the proposed alteration or amendment must be presented at a regular annual business meeting of the Society; (2) within six months after the meeting at which such alteration or amendment is presented the Secretary shall send to each member of the Society a suitable ballot to be marked, signed and returned to the Secretary prior to the following annual meeting; (3) the returned ballots shall be presented at said following meeting; (4) to effect the proposed alteration or amendment two-thirds of the returned ballots must favor it."

The Executive Committee voted that requests for nominations to Fellowship in the Society be sent out by the Secretary prior to the next annual meeting.

The Executive Committee voted that C. H. KENNEDY, Managing Editor of the Annals be empowered to select three members of the Editorial Board for the next three year term. STANLEY E. FLANDERS, Riverside, California; C. H. CURRAN, New York City, and C. F. SATTERTHWAIT, Urbana, Illinois, are the new members of the Editorial Board.

The Executive Committee voted to recommend to the Society the following statement of policy: "That it is contrary to the policy of the Entomological Society of America for any member to use the Society's name in advertising either commercial projects or personal services. Violation of this policy by any member shall be considered a sufficient reason for cancelling his membership."

The Executive Committee voted to hold the 1937 annual meeting at Indianapolis, Indiana, at the same time as the meetings of the American Association for the Advancement of Science.

The Executive Committee adjourned at 10:00 P. M.

The Society has suffered the loss by death of the following seven members: FOSTER H. BENJAMIN, ANDREW NELSON CAUDELL, COL. WILLIAM B. EWERS, JUSTUS WATSON FOLSOM, WARREN ELMER HINDS, ALBERT PITTS MORSE and FENNER SATTERTHWAITE STICKNEY.

FOSTER H. BENJAMIN, who became a Member of our Society in 1915, was born in Brooklyn, New York, September 18, 1895. He died after a brief illness on January 24, 1936, in Washington, D. C., where he was a member of the staff of the Bureau of Entomology and Plant Quarantine stationed at the United States National Museum. As a boy he was encouraged and directed in the study of insects by GEORGE P. ENGELHARDT and JACOB DOLL, of the Brooklyn Museum. He received the Bachelor's degree at Cornell University in 1920 and his Master's degree from the same institution in 1921. While an undergraduate at Cornell he enlisted in an aviation unit of the Navy and served in the World War from April, 1917, until the end of the war. After taking his Master's degree at Cornell he served with the Mississippi State Plant Board as Assistant Entomologist. In 1922 he went to Decatur, Illinois, as Curator of the William Barnes Collection and served in that capacity until 1927. In the latter year he joined the staff of the Bureau of Entomology where he was assigned to work on the Mexican Fruit Fly at Brownsville, Texas. In 1929 he was transferred to Florida where he took an active part in the campaign against the Mediterranean Fruit Fly and in 1931 was transferred to the taxonomic staff of the Bureau of Entomology and Plant Quarantine at the United States National Museum, Washington, D. C. In 1920 he was married to MARY ANNE SHERIDAN, of Ithaca, New York. His wife and two children, RICHARD, age 13, and MARY JULIA, age 6, survive him. During his entomological career he contributed a long series of taxonomic papers dealing with the Lepidoptera. He was a sincere friend, a kindly man, ready and eager to help wherever needed and devoted to his family, his friends and the science of Entomology.

ANDREW NELSON CAUDELL, a Member of our Society since 1918 and Fellow since 1927, was born in Indianapolis, Indiana, August 18, 1872, and died in Washington, D. C., March 1, 1936. His youth was spent in the state of Oklahoma, where he became a student at the Oklahoma Agricultural College in 1895. Later

he was an assistant in Entomology at the same institution. For a short time in 1898 he was connected with the Gypsy Moth work and with the Agricultural College at Amherst, Mass. In 1898 he joined the Division of Insects, U. S. Department of Agriculture, and was made custodian of the Orthoptera in the United States National Museum, a position which he held until his death. In 1900 MR. CAUDELL married PENELOPE LEE CUNDIFF, who with one daughter and one granddaughter survive him. He early became a recognized authority on the Orthoptera and published many important papers on the classification of these insects. He also did an enormous amount of indexing work on the Lepidoptera. Among the more important indexes compiled by him is a complete card index of the food plants of North American Lepidoptera and the voluminous index of all the American literature on Lepidoptera up to 1925. He was a member of the American Association for the Advancement of Science, the American Association of Economic Entomologists, the Washington Academy of Sciences, the Entomological Society of Washington, as well as our own Society. He was a staunch friend and an excellent scientist.

COL. WILLIAM B. EWERS, a Charter Member of our Society, was born August 5, 1871, and died on July 3, 1935. He received the degree of M.B. at the University of Pennsylvania in 1894. He served overseas during the World War with the Medical Corps of the U. S. Army. He had resided at Summerset, Bermuda, for some years prior to his death.

JUSTUS WATSON FOLSOM, a Charter Member of our Society and Fellow since 1907, was born September 2, 1871, at Cambridge, Massachusetts, and died September 24, 1936, at Vicksburg, Mississippi. He received the degree of B.Sc. in 1895 and that of D.Sc. in 1899 from Harvard University. He was professor of Natural Science at Antioch College, Yellow Springs, Ohio, for one year, 1899–1900. From 1900 to 1923 he served as instructor in Entomology, associate in Entomology and assistant professor in Entomology at the University of Illinois. In 1925 he became entomologist with the Bureau of Entomology and served in that position at the Tallulah, Louisiana Laboratory of the Division of Cotton Insect Investigations up to the time of his death. DR. FOLSOM was interested in many phases of entomology and his publications include papers on the anatomy, physiology, and ecology of insects. He had an international reputation as an authority on Collembola and Thysanura and published numerous systematic papers on these groups. His textbook, "Entomology with Special Reference to its Ecological Aspects," has been widely used during the past twenty-five years. He was a Fellow of the American Association for the Advancement of Science. He served as president of our own Society during the year 1931. He was a member of the American Association of Economic Entomologists serving as Vice-President during 1932, when he was chairman of the Cotton States Branch. He was also a member of the Ecological Society of America and of the Cambridge Entomological Club, serving as president of the latter organization in 1900.

WARREN ELMER HINDS, a Charter Member of our Society and Fellow since 1924, was born September 20, 1876, at Townsend, Massachusetts, and died January 18, 1936, at Baton Rouge, Louisiana. He received the degree of B.Sc. in 1899 and the degree of Ph.D. in 1902 from Massachusetts State Agricultural College. From 1902 to 1907 he was a special field agent of the U. S. Department of Agriculture. In 1907 he became Professor of Entomology at the Alabama Polytechnic Institute and also served as Entomologist for the Alabama Experiment Station. In 1924 he went to Louisiana as Entomologist with the Louisiana Experiment Station and Extension Service. Since 1929 he had been Entomologist with the Louisiana Experiment Station. In 1903 he married EDITH GODDARD GRAY, of Templeton, Massachusetts, who survives him. He served as President of the American Association of Economic Entomologists in 1934. He was a delegate from that Society in 1932 to the Centennial of the French Entomological Society and the Fifth International Entomological Congress in Paris. He had also served as Vice-President of the Executive Committee of the Louisiana State School for the Blind and Deaf in 1932. He was the author of numerous papers on economic entomology and was interested in the study of the Thysanoptera of North America.

ALBERT PITTS MORSE, a Charter Member of our Society and a Fellow since 1914, was born February 10, 1863, at Sherborn, Massachusetts, and died April 29,

1936, at Wellesley, Massachusetts. He was for many years a member of the faculty of Wellesley College and later, Curator of Natural History at the Peabody Museum at Salem, Massachusetts. He was also a member of the Nuthall Ornithological Club, the Essex County Ornithological Club, Forest and Science Club, Boston Society of Natural History and Cambridge Entomological Club. He was President of the latter Society in 1902 and 1903. He left an enduring monument in his "Manual of the Orthoptera of New England," probably as fine a regional entomological study as has been produced in America.

FENNER SATTERTHWAITE STICKNEY, a Member of our Society since 1917, was born at Wilson, North Carolina, August 6, 1892, and died at Whittier, California, August 15, 1936. His early training was received in North Carolina and Hawaii. He received the degree of B.Sc. from the University of California in 1916, the degree of M.Sc. in 1918 and the degree of Ph.D. in 1921 from the University of Illinois. He also carried on advanced study at Stanford University. During the World War he served in the Sanitary Corps of the Army. In 1921 he undertook a study of scale insects of date palms in the Coachella Valley in California for the Federal Horticultural Board. His studies were continued under the Bureau of Entomology and broadened to include other date insects and mites. At the completion of these studies he was transferred to work on the citrus red scale at the Bureau of Entomology and Plant Quarantine Laboratory at Whittier, California, the position which he held at the time of his death. He was a member of the American Association for the Advancement of Science, the American Association of Economic Entomologists, the Ecological Society of America, and the Pacific Coast Entomological Society.

Following the reading of these brief memorials, the members stood in silent respect of these men lost to the Society through death.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary.*

On motion the Secretary's Report was accepted.

REPORT OF THE TREASURER

CURRENT FUNDS

RECEIPTS

Balance on hand in Bank, Dec. 28, 1935 (See Annals XXIX, p. 186)	$1,436.30
From Annual Dues of Members to December 16, 1936	2,923.14
Life Membership Fees from G. W. Simpson and C. W. Sabrosky	100.00
Payment on Loan by Thomas Say Foundation, J. J. Davis, Secretary	100.00
Contribution for Badges used at Annual Meeting, from Ward's Natural Science Establishment	5.00
Transferred from Permanent Fund	500.00
Sale of Nine Membership Lists	2.25
Total	$5,066.69

EXPENDITURES

Postage, including 2,000 three-cent stamped envelopes and 1,000 one and one-half-cent stamped envelopes	$ 104.13
Union of American Biological Societies for support of Biological Abstracts	50.00
Printing Letterheads and Envelopes for President and Secretary-Treasurer	9.00
Envelopes, Rubber Stamps and New Journal	5.05
Spahr and Glenn Printing Co., Printing, December, 1935, Annals, March, June and September, 1936, Annals	2,626.77
Printing Preliminary Announcements, Blank Forms, and Programs	78.50
Exchange on Checks at Bank	10.95
Clerical Services	26.00
Checks Returned by Bank	17.00
Payment of Loan by Thomas Say Foundation, J. J. Davis, Secretary, Transferred to Permanent Fund	100.00

Life Membership Fees of G. W. Simpson and C. W. Sabrosky, Transferred to Permanent Fund	100.00
Telephone and Telegraph Charges	6.06
Express on Secretary's Books and Supplies, Lawrence, Kansas, to St. Paul, Minn.	4.63
Five Hundred Identification Badges for Annual Meetings	35.00
Total	$3,173.09
Balance in Bank, December 16, 1936	1,893.60
	$5,066.69

LIABILITIES

The Society owes the publishers for the December, 1936, Annals. Of the above cash receipts for dues, $1,194.50 is for 1937 dues.

PERMANENT FUND

RECEIPTS

In Savings Account of People's State Bank, Lawrence, Kansas, December 28, 1935	$3,444.59
Interest on Savings, June 22, 1935, to December 27, 1935	32.88
Interest on Liberty Bond 45554-D	.71
Payment by J. J. Davis on Loan to Thomas Say Foundation	100.00
Interest on Savings, March 20, 1936, to October 1, 1936	26.90
Interest on Liberty Bond 45554-D	1.44
Payment of Two Life Memberships	100.00
Total	$3,706.52

EXPENDITURES

Transfer from Permanent Fund to Checking Account as authorized by Executive Committee at 1935 Annual Meeting	$ 500.00
Balance in Savings Account, St. Anthony Park State Bank, St. Paul, Minn.	$3,206.52
One Liberty Bond, 45554-D	50.00
Balance in Permanent Fund	$3,256.52

RESOURCES

Liberty Bond 45554-D	$ 50.00
Balance in Savings Account	3,206.52
Balance in Checking Account	1,893.60
Total	$5,150.12

In addition to the above, the Thomas Say Foundation is in debt to the Society to the extent of $100.00.

Respectfully submitted,

CLARENCE E. MICKEL, *Treasurer.*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS

I wish to report that over 800 pages of matter have been published in Volume 29 for 1936, as against 519 pages in the volume for 1935. This increase in size has been due to three things: (1) Payment into the treasury of back dues by members in arrears. (2) A grant of $500.00 by the Executive Committee from the permanent fund. (3) A small over-run into the 1937 income of the Annals to clean up manuscript on hand. This leaves on hand enough manuscript to fill the March issue and part of the June issue, 1937. Without the grant from the

permanent fund the volume for 1936 would have been slightly larger than that for 1935, which indicates that the Annals is already feeling the up grade in prosperity.

A special effort has been made to keep the quality of illustrations up to the best. The quality of manuscript submitted during the past year has been the highest for any of the fifteen years that the present editor has been working on the Annals. We wish particularly to thank the members of the Society for this high grade of articles, and wish to call the attention of the Society to this as evidence that the Society has never been in a more healthy condition.

We wish to thank the assistant editor, Mr. Birely J. Landis, who took full charge of the September issue, and Dr. D. J. Borror and Dr. Ralph Davidson, who have done heavy work on the December issue.

The financial summary follows:

RECEIPTS

Non-member Subscriptions	$ 598.13
Sale of Back Numbers	169.65
From Authors for Cuts	463.65
From Authors for Printing Costs	10.00
Bank Balance from 1935	3.36
	$1,244.79

EXPENDITURES

To Engravers	$ 561.78
Office Help	353.00
Postage	81.99
Miscellaneous	98.02
To Secretary	150.00
	$1,244.79

Vouchers have already been submitted and approved by the Auditing Committee.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

On motion, the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

RECEIPTS

Balance on hand, December 21, 1935	$113.14
Received from 1935 Sales, not previously reported	23.40
1936 Sales of Volume I (4 copies)	11.70
1936 Sales of Volume II (8 copies)	38.00
1936 Sales of Volume III (7 copies)	26.40
Interest July 1, 1934, to December 31, 1935	3.74
	$216.38
1936 Sales Unpaid	13.50
	$202.88

EXPENDITURES

Payment on Loan to Entomological Society of America	$100.00
Commission to C. C. Thomas for sale of six volumes	3.00
Express and Postage on Books	3.40
Miscellaneous Postage	.75
Total Expenditures	$107.15
Balance in Purdue State Bank, December 17, 1936	$ 95.73

There is a balance due the Entomological Society of America of $100.00. Also a total of $13.50 is still due the Foundation for one copy of Volume I and three copies of Volume III, payment for which has not yet been made.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the report was accepted subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have carefully examined the accounts of the Treasurer of the Society, the Managing Editor of the Annals and the Treasurer of the Thomas Say Foundation for the year 1936, and have found them to be correct and properly balanced.

Respectfully submitted,

ALEXANDER A. GRANOVSKY, *Chairman,*
RAYMOND C. OSBURN,
HOWARD DEAY.

On motion, the report of the Auditing Committee was accepted.

REPORT OF THE NOMINATING COMMITTEE

Your Committee places in nomination the following Fellows of the Entomological Society of America, to fill the designated vacancies for the year 1937:

President—O. A. JOHANNSEN.

First Vice-President—A. G. RUGGLES.

Second Vice-President—A. C. KINSEY.

Secretary-Treasurer—CLARENCE E. MICKEL.

Two Members of the Executive Committee to Serve until 1939—P. B. LAWSON and S. A. GRAHAM.

Councilors to the American Association for the Advancement of Science—W. B. HERMS and O. A. JOHANNSEN.

One Member of Joint Committee on Insect Collections of America, to Serve until 1939—JOSEF KNULL.

One Member of Joint Committee on Advancement of Official Entomology—J. J. DAVIS.

Respectfully submitted,

WM. A. RILEY, *Chairman,*
EDNA MOSHER,
A. F. SATTERTHWAITE.

On motion the report was accepted and the Secretary instructed to cast a ballot for the election of the persons nominated. This being done, they were duly elected.

REPORT OF THE JOINT COMMITTEE ON INSECT COLLECTIONS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA AND THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

For the second time committees on insect collections for the Entomological Society of America and the American Association of Economic Entomologists have reported as a single or joint committee. A report for private collections is again omitted this year because there are not enough new collections or outstanding additions to old collections to justify a printed report at this time. Statements from 31 institutions have been received and compose the report of the committee for this year.

By action of the presidents of both societies, T. H. FRISON has served as chairman of this joint committee.

Respectfully submitted,

FRANK E. LUTZ (Entomological Society of America),
C. P. ALEXANDER (Entomological Society of America),
C. F. W. MUESEBECK (Entomological Society of America),
E. C. VAN DYKE (American Association of Economic Entomologists),
H. H. KNIGHT (American Association of Economic Entomologists),
W. J. BROWN (American Association of Economic Entomologists),
T. H. FRISON, *Chairman* (American Association of Economic Entomologists).

Academy of Natural Sciences of Philadelphia, Pa.—During the year 1936 the preparation of the extensive African collections secured by the George Vanderbilt African Expedition of 1934 was completed, and this series of approximately 16,000 specimens, taken in a cross-section survey of Central Africa, is now available for study. Work has been taken up in a number of lines by staff members and specialists elsewhere.

Of the accessions during the year 1936 two stand out of particular importance. One was the presentation to the Academy by Mr. John W. Angell of his exceptionally complete collection of Lucanidae. The exotic series is now in our charge, thus giving the Academy a very full representation of the frequently quite rare species of the family, while the North American representation will subsequently come to us on the completion of studies with which Mr. Angell is now engaged. The section already incorporated includes 1690 specimens. The collection will be preserved as a separate unit, arranged in the same cabinets with, but distinct from, the series previously in our possession, thus preserving its individual character but facilitating consultation by the specialist. The second addition of conspicuous character was the presentation to the Academy by Dr. B. Preston Clark, long a Life-Member of the Academy, of a most important representation of authentically determined Sphingidae, totalling 395, making a total of 421 species and subspecies presented by him in recent years, and now giving a grand total of 712 forms of these interesting and often exceedingly rare moths represented in the Academy series. Many of the forms included in Dr. Clark's recent gift are known solely from a few specimens. Owing to this extremely valuable gift the Academy's representation of the family now stands next in importance in America to Dr. Clark's unrivalled series.

The other principal accessions of the year were: 1285 Costa Rican insects from Prof. Anastasio Alfaro; 404 South American butterflies and moths from Mr. W. J. Coxey; 625 Orthoptera from South America and India, purchased; 4212 insects of all orders from the Eastern United States and South America, from James A. G. Rehn and John W. Rehn; 320 specimens from New York and Arizona from A. N. Calvocaresses; 203 specimens from the Eastern United States from John W. Cadbury; 172 specimens from Guatemala from L. Satterthwaite, Jr.; 103 specimens from various localities from Morgan Hebard; 100 specimens from New Jersey from Dr. Emlen P. Darlington; a very important collection of Mallophaga, secured on four Peruvian and one Bolivian ornithological expeditions of the Academy, representing sixty-four species and containing types of one new family, nineteen new genera and sixty species and subspecies recently described by M. A. Carriker, Jr. Other lots of entomological material have been received from thirty additional sources, aside from a very extensive series of Mexican Orthoptera collected in 1936 by Mr. H. Radclyffe Roberts, a Research Associate of the Department, and now in course of preparation. A summary of this very important representation, which is accompanied by full field observations, will be included in the report for 1937.

The major operative change in the Department during the year was the removal of the Library of the American Entomological Society to the book stack of the Academy. This was made necessary by the internal reconstruction of the North Building of the Academy to provide needed space for the growing laboratories of the Department of Vertebrate Zoology. It is hoped that the year 1937 will see the Department of Entomology housed in the more ample and adaptable space now being vacated by the Academy's Department of Vertebrate Zoology. Tentative plans for installation and arrangement of the series, which will facilitate the consultation of the collections, have been made.—JAMES A. G. REHN.

American Museum of Natural History, New York, N. Y.—Approximate number of new specimens acquired, 50,000. Fossil insects consisting of about 1500 specimens, many of which are types, were transferred from the Department of Geology to Department of Entomology. About 7500 butterflies (Lycaenidae) were received as a gift from Mr. E. I. Huntington. The Museum Expedition to Panama secured over 21,000 specimens, mostly butterflies and moths. These specimens were collected by Dr. Frank E. Lutz, Dr. W. J. Gertsch, and Mr. Wm. C. Wood. Approximately 400 types were added to the collection.—FRANK E. LUTZ.

Bernice P. Bishop Museum, Honolulu, Hawaii.—Approximately 3000 pinned specimens were acquired. The E. M. Ehrhorn collection of Coccidae was obtained as an indefinite loan from the University of Hawaii. Two thousand or more specimens were collected on the Micronesian Expedition, from Kusaie, Ponape, Truk, Yap, and Pelau. Large numbers of types of Pacific Island insects are being returned by specialists to whom collections have been loaned for study. Collections are being arranged in unit boxes. A new slide cabinet and case for Schmidt boxes have been added to the storage equipment.—E. H. BRYAN, JR.

Boston Society of Natural History, Boston, Mass.—The insect collections of this institution are housed in the building used by the Society since 1863, and recently named the New England Museum of Natural History. About 1915, the Society adopted the policy of restricting its collections to the geographical area of New England, thus permitting the museum to develop more logically and provide adequate space and care for its material.

The insect collections, which include all land and fresh-water arthropods exclusive of Crustacea, have received approximately 2000 specimens during the past year. The most notable accession was a collection of the Lepidoptera of Martha's Vineyard, donated by Dr. F. M. Jones. It consists of more than a thousand specimens representing over 900 species. Another outstanding gift was 75 lots of identified myriapods from Dr. C. H. Blake.

Since the last report to the committee on insect collections, most of the important slides have been rearranged in new boxes, and a large amount of alcoholic material has been put in order.

In November and December of 1936, a census was taken of the study collections, exclusive of the Harris Collection which is kept separate. They were found to be over 71,108 identified pinned specimens, 471 vials of alcoholic material, and 437 slides. The total number of named species is 10,605, of which the Insecta account for 10,106. The figures for the different groups are as follows, asterisks being used to indicate those groups which contain types: Symphyla, 1; Diplopoda, 18; Chilopoda, 5; Pseudoscorpionida, 1; Phalangida, 6; Acarina, 6; Araneida, 462; Collembola, 4; Orthoptera, 105; Dermaptera, 4; Thysanoptera, 1; Isoptera, 1; Corrodentia, 27; Mallophaga,* 87; Anoplura*, 12; Hemiptera*, 694; Odonata,* 158; Plectoptera,* 44; Megaloptera, 7; Neuroptera,* 35; Mecoptera,* 16; Trichoptera,* 88; Lepidoptera*, 1510; Diptera,* 2919; Siphonaptera, 12; Coleoptera,* 2981; Hymenoptera,* 1367.—RICHARD DOW.

Brigham Young University, Provo, Utah.—Seven thousand specimens were collected in faunistic work. Three thousand were collected in the Garfield-Kane counties faunistic study. Eight new types were added this year.
—VASCO M. TANNER.

California Academy of Sciences, San Francisco, Calif.—This is the largest insect collection in western North America, now well over 900,000 specimens and growing normally at the rate of 10,000–15,000 a year. Special collections added consist chiefly of the Charles Leng Collection of Carabinae and Dytiscidae.
—E. P. VAN DUZEE.

Canadian National Collection, Ottawa, Ont.—Ten thousand new specimens were acquired from faunistic surveys conducted in Nova Scotia, Southern Quebec, Ottawa district of Ontario and Southern British Columbia. Type material of 112 North American species was added to the collection. The collection now contains type material of 4175 North American species.—J. M. MCDUNNOUGH.

Clemson Agricultural College and Experiment Station, Clemson, S. C.—Perhaps 2000 to 3000 specimens were collected during 1936. With new and larger quarters in a new Agricultural Building now nearly completed, we expect to start getting our collection into the standard glass-top cases, tray system. Much of the duplicate and class-work material will probably still be kept in Schmidt-type

boxes, of which we have several hundred. Our collection is primarily of South Carolina fauna.—FRANKLIN SHERMAN.

Colorado State College of Agriculture and Mechanic Arts, Fort Collins, Colo.—Collections of the past year include about 3000 specimens of Colorado insects. A donation of Chilean insects from Mr. Leon Miller numbered about 350 specimens, with 40 determined species. During 1936, the named collection was increased by 350 species, 20 of these being represented by type material in the Aphididae, Cicadellidae, Diptera, and Apoidea.—MAURICE T. JAMES.

Commonwealth of Pennsylvania, Harrisburg, Pa.—This year about 500 specimens, including about 40 species new to the collection were added.—R. M. BAKER.

Connecticut Agricultural Experiment Station, New Haven, Conn.—About 7000 insects were collected and pinned during 1936. A small collection of Connecticut Tipulidae donated by Dr. Alexander, added about 50 species to the collection. Over 10,000 specimens of Arachnida were collected during the year. The insect collection contains over 7000 species and varieties of which 95 to 97 per cent is Connecticut material; 198 types and paratypes.—W. E. BRITTON.

Illinois State Natural History Survey, Urbana, Ill.—During 1936 the more notable additions to our collection were (1) 7,000 leafhoppers, representing the third year's efforts in the survey of the Illinois species, (2) 1,000 vials of Plecoptera, (3) 600 pinned specimens and 2,000 vials of Trichoptera, and (4) about 500 pinned sawflies. Concurrently with these about 5,000 pinned specimens and 500 vials of miscellaneous insects were collected. Additions to the ectoparasite collection have continued at intervals throughout the year. Types of approximately 60 species were added to the collection, chiefly in leafhoppers, stoneflies, sawflies and chalcid flies.—HERBERT H. ROSS.

Kansas State College of Agriculture and Applied Science, Manhattan, Kan.—The chief additions were about 4,000 Chalcidoidea, chiefly *Harmolita*, *Eurytoma* and their parasites, from Prof. D. A. Wilbur's pasture insect studies. In addition about 300 miscellaneous specimens were added.—G. A. DEAN.

The Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kan.—Approximately 50,000 new specimens of North American insects have been added; 13,397 specimens have been determined and added to the collection, including 1674 species, 570 of which were new to the collection, and types of 91 new species. In addition, several thousand exotic insects have been received. Doctor Beamer and party, including two advanced students, collected in the western states.—H. B. HUNGERFORD.

Massachusetts State College, Amherst, Mass.—Two thousand new specimens were acquired. These include collections of Coleoptera (local) donated by C. A. Frost, and extensive collections of economic species from Puerto Rico and Brazil.
—C. P. ALEXANDER.

Montana Experiment Station, Bozeman, Mont.—Approximately 1500 new specimens were acquired. The donation of the complete Folsom Collection of Aptera is the greatest single addition to the collections of the institution received during the past year. Collections of parasites of the sugar beet webworm and Say's grain bug have increased our collections in the parasitic groups. Practically all of our parasitic Diptera have been determined during the past year. The unit tray system is replacing the drawer system of housing the collections.
—HARLOW B. MILLS.

Museum of Comparative Zoology, Cambridge, Mass.—The largest addition is the collection of the late F. A. Eddy, of Bangor, Maine. Years ago Mr. Eddy purchased the A. S. Fuller collection of North American Coleoptera, and through a long life added greatly to it. Later he bought many exotic insects, chiefly Coleoptera and Lepidoptera. Most of the insects from Maine will be given to the University of Maine, but there are fully 40,000 specimens added to the M. C. Z. Mr. Darlington gave about 10,000 North American beetles, and on a collecting trip in Cuba, mostly in Oriente, obtained over 10,000 miscellaneous insects and spiders. We have also acquired the Coleoptera and miscellaneous insects (about 6000) of the Tropical Plant Research Foundation of Baragua, Cuba, many of them identified.

Prof. Brues, Dr. Carpenter, and Mr. Parsons, on their trip for amber insects in Canada, obtained several thousand recent forms. Prof. Brues also gave about 1000 western Coleoptera.

Dr. Bequaert brought back from Colombia several thousand insects and arachnids; he also gave two hundred Hymenoptera from the Congo.

Mr. D. Davenport collected nearly 1000 insects in southern Canada, and also gave 250 Colorado butterflies.

From Mr. Clench and Mr. Pomerat came about 1000 specimens from the Caribbean region; Prof. Emerson sent ants from Panama, and there have been numerous smaller gifts.

By purchase we obtained 2300 Orthoptera, Neuroptera, Sphegidae, Psammocharidae, and Formicidae from Formosa and Hainan, and 1400 Arachnida from Hainan; 500 Neuroptera and 300 Coleoptera from southern India, some flies from Rhodesia and Jamaica, spiders from Jamaica, Neuroptera and Diptera from Arizona, and Coleoptera from California, Paraguay, and New Guinea.

Dr. Brues has published the Philippine Phoridae, over 75 new species; Prof. Metcalf has a paper on the Panama Fulgoridae (22 new species); M. Thery has named the Old World Buprestidae (15 new species); Prof. Forbes has finished four families of the Panama Lepidoptera (7 new species); Prof. Hull has identified the exotic Syrphidae (12 new species); the Curator has prepared papers on Formosan and Philippine Neuroptera, and various smaller papers have been based on the collections.

Two hundred and twenty-five boxes were added, and two hundred boxes of the Eddy collection are the same size as ours.

Types of 464 species have been catalogued during the year.

An exhibit of insect architecture has been placed in the public halls.

—NATHAN BANKS.

New Jersey Agricultural Experiment Station, New Brunswick, N. J.—About 500 specimens, including 27 species new to the collection, were added this year.

—T. J. HEADLEE.

Ohio State University, Columbus, Ohio.—Insects belonging to the University collection and housed temporarily in the Ohio State Archaeological Museum have been returned to the Department of Zoology and Entomology. This includes all of the Diptera accumulated under the late Prof. J. S. Hine up to the year 1925, with many types. An extensive collection of Stratiomyidae was donated by Dr. R. C. Osburn; Drs. Mary A. Auten and Dorothy M. Johnson donated types of Cicadellidae and Dr. G. T. Knowlton and W. G. Stehr contributed material to our collection. The Ohio Biological Survey, under the direction of Prof. Herbert Osborn, added considerable Homoptera. Many others contributed insect material during the year. Approximately 20,000 southwestern insects were added by the curator. During 1936 we have added 8 more insect cabinets to our permanent equipment.—J. N. KNULL.

Oregon State Agricultural College, Corvallis, Ore.—Five thousand new specimens were acquired. Special collections include 2000 to 3000 aquatic insects. New housing facilities include one room devoted to the insect collections, 22½′ x 23½′ x 12′. Fourteen museum cases with 24 trays to each case. The trays are 19″ x 17″ x 2.5″ (outside measurements), 336 trays total.—D. C. MOTE.

Purdue University and Agricultural Experiment Station, Lafayette, Ind.—Seventy-five thousand specimens were acquired in 1936. These include especially the Blatchley collections of Coleoptera (including Rhynchophora), Hemiptera, Orthoptera and Rhopalocera, which were purchased, and faunistic surveys by Deay and Gould which added perhaps 10,000 Hemiptera and Homoptera. The Blatchley collections contain 500 types.—J. J. DAVIS.

San Diego Society of Natural History, San Diego, Calif.—Eleven thousand five hundred fifty-nine new specimens were acquired, including types of one species.—CLINTON G. ABBOTT.

South Dakota State College, Brookings, S. D.—Five thousand specimens of Orthoptera and 10,000 specimens of other orders were added to the collection. Special collections resulting from faunistic surveys included chiefly Orthoptera and Meloidae. All collections are in Schmidt or Comstock boxes. All Comstock boxes are kept in fireproof metal cases. In Comstock boxes insects are kept in cardboard trays.—H. C. SEVERIN.

Texas Agricultural Experiment Station, College Station, Texas.—Five thousand specimens were added to the collection, mainly Coleoptera, Diptera, Hemiptera, Homoptera, and Lepidoptera, and included 14 holotype specimens.

Housing facilities include 438 Schmidt boxes and 24 Cornell cases. There are approximately 60,000 specimens in the collection, of which about half are specifically determined.—H. J. REINHARD.

U. S. National Museum, Washington, D. C.—From January-December, 1936, 89,336 new specimens were acquired, including 708 types.

Special collections purchased or received by donations include the following: By purchase—Alan S. Nicolay's collection of Cleridae of about 850 specimens, which includes the Chas. Schaeffer collection of Cleridae; from Fritz Hoffman, 680 Brazilian moths. By exchange—From the Indian Museum, Calcutta, 247 named Indian Jassidae, new to our collection. By gift—The collection of Pacific Northwest Lepidoptera made by John F. Gates Clarke, approximately 10,000 specimens; from Frank Johnson, New York City, 2,276 Brazilian Lepidoptera; about 800 specimens of miscellaneous insects from Greece, donated by R. C. Shannon; over 5,000 miscellaneous insects from China received from David C. Graham. By transfer from other government agencies—20,000 ectoparasites of rodents from the National Institute of Health; 44,000 miscellaneous insects from the Bureau of Entomology and Plant Quarantine.—E. A. CHAPIN.

*University of California.*A. Berkeley, Calif.—A moderate sized collection in all orders for reference: B. Davis, Calif.—A small collection for student reference; C. Riverside, Calif.—A fair sized collection particularly rich in small parasitic Hymenoptera, Coccidae and Bees (Timberlake Coll.).—E. C. VAN DYKE.

University of Colorado Museum, Boulder, Colo.—About 7000 new specimens were acquired. Our collections are in confusion owing to transfer to new cases and imminence of moving to new building. Many specimens were donated from the T. D. A. Cockerell collection. Special collections include: Insect survey of University Camp, the University's summer field station in western Boulder County, about 9500 feet altitude and within a few miles of the Continental Divide. Mostly not yet identified, collected by Helen E. Rodeck, Hugo G. Rodeck, Gordon Alexander. Orthoptera all identified by Gordon Alexander. New additions of typic material include allotypes, paratypes, cotypes, homotypes: Diptera, 20; Coleoptera, 1; Hymenoptera, 6. New housing facilities include transferring collection to glass-topped steel drawers in steel cases. Diptera all transferred, Hymenoptera in progress. After September 1, 1937, Museum will occupy new fireproof Museum Building. The Museum has a large number of fossil insect types, mostly Florissant, some Green River, a few Creede and others, as follows: *Jurassic, New Mexico*—Coleoptera (?) 1. *Pierre Cretaceous, Colo.*—1. *Green River Eocene*—Odonata, 2; Homoptera, 2; Hemiptera, 2; Lepidoptera, 2; Diptera, 6; Coleoptera, 1; Hymenoptera, 2. *Eocene, North Park, Colo.*—Coleoptera, 4. *Oligocene, Baltic Amber*—Homoptera, 1; Diptera, 1. *Florissant Miocene, Colo.*—Arachnoidea, 8; Orthoptera, 8; Isoptera, 1; Homoptera, 5; Hemiptera, 4; Odonata, 8; Neuroptera, 9; Mecoptera, 1; Trichoptera, 4; Leptidoptera, 5; Diptera, 49; Coleoptera, 49; Hymenoptera, 71. *Creede Miocene, Colo.*—Hymenoptera, 1. *Tertiary, Kudia River, Siberia*—Trichoptera, 1.—H. G. RODECK.

University of Kentucky, Lexington, Ky.—About 750 new specimens were acquired. Dr. Paul O. Ritcher has identified and rearranged the collection of May Beetles (Phyllophaga) adding about 200 specimens.—W. A. PRICE.

University of Minnesota, St. Paul, Minn.—Approximately 51,000 specimens have been added to the collection during the year. Mr. C. N. Ainslie, of Sioux City, Iowa, has presented the collection with an additional 6,500 specimens, most of which are determined. About 1500 specimens of insects were received as gifts from other donors. The most important purchase made during the year was 3000 specimens of Arizona Mutillidae collected by Mr. F. H. Parker. Approximately 800 specimens of determined Mutillidae were added to the Minnesota collection in return for determinations made for various institutions and individuals. As the result of special collecting and study by graduate students 1076 specimens of the Coleopterous genus *Trichiotinus* and 4462 specimens of mosquitoes were added to the collection by Dr. C. H. Hoffmann and Dr. W. B. Owen respectively, and 4651 specimens of the Coleopterous genus *Phyllophaga* were added to the collection due to the studies of Dr. A. A. Granovsky. Most of this material consisted of Minnesota specimens. In addition to these about 2000 specimens of Minnesota spiders and 30,000 specimens of Minnesota insects were added to the collection by various collecting parties in the state. During the year the entire Orthoptera collection

has been rechecked and arranged, and the study of Minnesota mosquitoes has been completed so that the collection of the latter now contains several thousand determined and labeled mosquitoes. Both the mosquito collection and the *Phyllophaga* collection has been completely catalogued during the year. At the present time the catalog of the collection contains some 20,000 entries of approximately 30,000 specimens.

Material from the University collection is available to responsible students making a study of any particular group.—CLARENCE E. MICKEL.

University of Missouri, Columbia, Mo.—Five thousand new specimens were acquired. We are transferring the entire collection from the multiple block system to the multiple pasteboard box system.—L. HASEMAN.

Utah Agricultural Experiment Station, Logan, Utah.—Five thousand pinned specimens and prepared slide mounts were added to the collection. Much of the material was taken in a series of light traps operated throughout northern Utah. Other material was taken in connection with range and crop-plant studies. Approximately 100 type and paratype aphid slides of 20 species, and 20 specimens of six species of Diptera.—G. F. KNOWLTON.

REPORT OF THE COMMITTEE ON RESOLUTIONS

1. WHEREAS, the success of the Thirty-first Annual Meeting of the Entomological Society of America has been due in large part to the excellent work of the joint committee on arrangements of the Entomological Society of America and the American Association of Economic Entomologists;

Therefore, be it Resolved, that the thanks of the Society be extended to this joint committee and particularly to MESSRS. T. J. HEADLEE and C. H. HADLEY, the chairman, for the excellence of their arrangements for our meetings and entertainment, and C. C. HAMILTON, for the excellent way in which the entomological exhibits were arranged.

2. WHEREAS, the Society has learned with sorrow of the deaths of FOSTER H. BENJAMIN, ANDREW N. CAUDELL, COL. WM. B. EWERS, JUSTUS W. FOLSOM, WARREN E. HINDS, ALBERT P. MORSE, and FENNER S. STICKNEY the past year;

Therefore, be it Resolved, that we hereby express our deep regret at the loss of these members and extend our sincerest sympathy to their families, and that a copy of this resolution be spread upon our minutes.

3. WHEREAS, the affairs of our organization have been so splendidly administered by the officers of the Society during the past year;

Therefore, be it Resolved, that the Society express its appreciation and thanks to the president, vice-presidents, secretary-treasurer and members of the executive committee for their faithful and efficient services.

4. WHEREAS, the Chalfonte-Haddon Hotel has provided excellent facilities for our meetings in Atlantic City;

Therefore, be it Resolved, that the thanks of the Society be expressed to the management of this hotel for the courtesies and hospitality extended.

Respectfully submitted,

O. A. JOHANNSEN, *Chairman*,
R. E. SNODGRASS,
W. H. WELLHOUSE.

REPORT OF THE COMMITTEE ON ADVANCEMENT OF OFFICIAL ENTOMOLOGY

The chairman reported informally that there is nothing special to report at this time, but that with the expected change from the use of emergency funds for numerous projects to regular appropriations it is to be expected that watchfulness will be necessary to maintain the entomological work of the government on a safe and useful basis.

Respectfully submitted,

E. F. PHILLIPS, *Chairman*.

Dr. J. C. BRADLEY called the attention of the Society to the next International Entomological Congress to be held in 1939 and that the necessary arrangements should be made.

On motion the question was referred to the Executive Committee with power to act.

Dr. P. P. CALVERT, the Society's councilor to the Union of American Biological Societies, presented the following communication from that organization:

> At a meeting of the Council of the Union of American Biological Societies held Monday, December 28, 1936, at 8:00 P. M., it was voted that councilors of the constituent societies present bring before their respective societies the suggestion that a contribution of $1.00 from each member for 1937 be made to Biological Abstracts. This is a smaller amount per member than that ($2.00) contributed by the American Society of Zoologists for each of the last three years. The object of this special contribution is to enable Biological Abstracts to go on during 1937, while efforts are being continued to obtain a permanent grant or endowment.

No action was taken by the Society.

On motion, the Society extended a vote of thanks and appreciation to Miss EDITH M. PATCH for the Annual Public Address given before the Society on Tuesday evening, December 29.

Following the transaction of the above business, the meeting adjourned.

The following exhibits were on display in rooms near the meeting place of the Society:

1. The Nutritional Requirements of Mosquito Larvae Grown Free from Living Microorganisms. WM. TRAGER, Rockefeller Institute, Princeton, N. J.
2. *Anthrenus vorax* Waterhouse, a Pest of Increasing Importance. E. A. BACK, Bureau of Entomology and Plant Quarantine, Washington, D. C.
3. Mechanocardiographic Method of Recording the Insect Heart Beat. J. F. YEAGER, Bureau of Entomology and Plant Quarantine, Washington, D. C.
4. Heterogonic Growth in Thysanoptera. J. D. HOOD, University of Rochester, Rochester, N. Y.
5. The Feeding Methods of Sucking Insects. A. A. GRANOVSKY, University of Minnesota, St. Paul, Minn.
6. Apparatus to Inject Quantitative Doses of Insecticides. N. E. MCINDOO, Bureau of Entomology and Plant Quarantine, Washington, D. C.
7. The Embryology of *Calendra callosa* Olivier. DAVID L. WRAY, Department of Agriculture, Raleigh, N. C.
8. Methods Used in Cataloging the Homoptera. Z. P. METCALF, College of Agriculture, Raleigh, N. C.
9. Improvements and New Technique Used in the Study of Insects. RICHARD LEWIS POST, Ward's Natural Science Establishment, Rochester, N. Y.
10. The American Dog-tick, *Dermacentor variabilis*, and the Chalcid Parasite, *Hunterellus hookeri*. (Living material of various stages of the tick; parasitized nymphs.) MARSHALL HERTIG, Harvard University Medical School, Boston, Mass.
11. Items of Laboratory Technique: a. Rearing of Fleas and Bedbugs; b. Whole Mounts of Insects in Hollow-ground Slides Made with the Dental Engine; c. Micro-scissors. MARSHALL HERTIG, Harvard University Medical School, Boston, Mass.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary.*

BOOK NOTICES

ODONATA, in "THE FAUNA OF BRITISH INDIA," by Lt.-Col. F. C. Fraser, I. M. S. Vol. I, Zygoptera, (Coenagriidae), pp. i-xiii and 1-423, 180 text figs., folding map, 1933; Vol. II, Zygoptera (Agriidae), Anisozygoptera, Anisoptera (Gomphidae), pp. i-xxiii and 1-398, 120 text figs., 4 pls. in colors, 1934; Vol. III, Anisoptera (Cordulegasteridae, Aeshnidae, Libellulidae), pp. i-xi and 1-461, 125 figs., 2 pls., folding map. 1936. Published by Taylor and Francis, Ltd., Red Lion Court, Fleet Street, London, E. C. 4. Price, bound, Vols. I and II, 25 shillings each ($6.13 plus 92 cents duty), Vol. III, 30 shillings ($7.33 plus $1.10 duty).

In the three volumes listed Col. Fraser has given odonatists a thorough monograph of the dragonflies of one of the richest faunal areas of the tropical and subtropical world. (From about the year 1917 to the present Col. Fraser has published over 100 papers on the Odonata of India, many of which were large and of a monographic nature.) Five hundred and thirty-seven species are listed in the three volumes for this area, one hundred and ninety-five of which have been described by the author himself in this or in preceding publications. Until Col. Fraser started collecting in India odonatists had the feeling that the Indian dragonfly fauna had been rather completely described by de Selys, Ris and others from material brought out by butterfly hunters and general collectors. But with fifty more new species Col. Fraser would have himself described one-half of the (probable total number of) dragonflies in that region. The region is particularly rich in highly specialized tropical forms and side-by-side with them various very primitive species. Col. Fraser has appreciated these opportunities and whenever possible has published on the larval forms and habits of the more interesting species. His work has cleared up much of the basic phylogeny of several puzzling groups. Thus his point of view and standards of work have been high.

The Tillyard system of naming the wing veins is followed. With each generic description is a figure of the wings. With each specific description are figures of the terminal abdominal appendages of the male. (Dragonflies appear to have been one of the first groups in which species were described on the genitalia of the male. Charpentier started this in 1825. The method has been in continuous use by all odonatists since.)

The first volume covers the family Coenagriidae (the English revised spelling for the more familiar Coenagrionidae). The second volume covers the Agriidae (the broad-winged Zygoptera) and an early family, the Gomphidae of the Anisoptera. Because of the characteristic wing patterns in many species of the Agriidae, illustrations of wings are not limited to use in generic descriptions in volume two. Because body color-patterns are characteristic features in the Gomphidae illustrations of these are frequently introduced. Volume two closes with two colored plates of the rainbow-hued wings of Rhinocypha and two colored plates of brilliantly colored Gomphines. I might add that one of the two living species of the Mesozoic Order Anisozygoptera flies in northern India and is treated in volume two. This species is known from the nymph only. Its adult form is looked for in every collection coming out of the mountains of northern India, but so far has not been captured. (The other living species of Anisozygoptera is described, adult and larva, from Japan.) Volume three is devoted to the remaining Anisoptera, the Cordulegasteridae, Aeshnidae and Libellulidae.

In this three-volume work Fraser has not only given us a very usable work on Indian Odonata in general, but he has redescribed and made available clear generic pictures of the majority of the Oriental genera. It will be a basic reference work in all studies of palaeotropical dragonflies. So far very few corrections have been made in the literature, of any of Col. Fraser's work. It is very sound.

Col. Fraser, who retired last year, is a distinguished surgeon in the Indian Army with years of major operative work to his credit. He was in charge of penal institutions in Mesopotamia during the Great War, later in India in charge of a medical college and at one time in charge of the Rangoon Gaol, comparable to an

American state penitentiary. His relaxation and exercise was the hunting of dragonflies and he has stated that it was his ambition to describe one species each evening. By whatever method so much was accomplished we have the fact of the extensive and very useful product. In the background we see the army methods of keeping fit physically and mentally.

We see one other factor not so highly developed in American university and scientific staffs. A staff man's time is highly respected. In the British Museum no one wanders into another man's office to pass the time of day. If a conference is necessary the seeker writes a note asking for the information or a conference, rings for an orderly who delivers it to the proper office, sometimes merely to an adjoining room. This system discourages idle talk and saves time. It is probably even more rigorous in army circles. Contrast with this the practice in some American schools where the College of Education suggests that the professor's office door should always open to a student seeking knowledge.

As much as we admire Col. Fraser's ability and work, we must close.—C.H.K.

CATALOGUS INSECTORUM SINENSIUM (Catalogue of Chinese Insects), by CHENFU F. WU. Vol. I, pages i-vi and 1-378, quarto. 1935. Published by The Fan Memorial Institute of Biology, Peiping, China, for sale by N. V. SWETS & ZEITLINGER, Keizersgracht 471, Amsterdam, Holland. Price, unbound, postpaid, Vol. I, $3.50; Vols. II-IV, $5.00 each; Vols. V and VI, $3.50 each. Subscription for the six volumes in advance, $20.00.

This encyclopaediac catalogue of the described species of insects of China lists in its six volumes about 19,000 species. According to the introduction its publication was completed in December, 1936. Professor Doctor Wu, Professor of Zoology, Yenching University, Peiping, and Visiting Professor, Cornell University, 1933–1934, has spent several years (1922–1936) with the assistance of a staff of expert help on the preparation of this work. After completion by this staff, parts were critically read by experts in the United States and Europe. Its preparation has been more or less a world project with financial support from the China Foundation for the Promotion of Education and Culture and from the Rockefeller Foundation. The work was finally put in shape during the year at Cornell, where Professor Wu had the use of the Entomological Library which under the supervision of the late Professor Crosby is as complete as money can make a technical library.

Volume I covers the following orders: Thysanura, Collembola, Orthoptera, Zoraptera, Isoptera, Neuroptera, Ephemerida, Odonata, Plecoptera, Corrodentia, Mallophaga, Embiidina, Thysanoptera and Anopleura. It is a straight species catalogue without keys or descriptions. The use of ordinal names and their arrangements reflects the Comstock system in use at Cornell and in general at present, rather than the later and probably more correct system used by Brues and Melander (1932) which is based on the work of Handlirsch (1908) and the work of later palaeontologists. However, we have yet to see a systematic work that places very primitive orders correctly. As for instance the Ephemerida with wings in the subimago, a late larval stage, which is the most primitive living winged order, is listed after four other winged orders including the Neuroptera with complete metamorphosis. Following the Ephemerida is the Order Odonata, a distinct offshoot from the very base of winged insects in general. Following this is the Order Plecoptera, which probably is below or related to very ancient orthopteroid insects. The order Neuroptera is entirely separated from its descendants, the so-called "neuropteroid orders."

This arrangement of orders in no wise impairs the usefulness of the work. A list of insects is just as convenient no matter in what volume any particular order may be found. Each order is a distinct entity.

We hope some day to find a general catalogue of insects which conscientiously gives references to the first use of ordinal, subordinal superfamily, family and subfamily names. We would like to see the names of the men who have made a conscious effort to think their way through some of the larger problems in taxonomy. This work is better than the average in that respect but falls far short of perfection. Generic names are fairly well handled in this matter. At least the author's name is always given. However, the section on Odonata is an abbreviated transcript of Needham, A Manual on the Dragonflies of China, 1930, and under each species is given first a reference to that work instead of the usual

reference to the author of the species which reference has to be looked up in the Needham work. We feel that such treatment trims some credit from the original authors of species names. It is good salesmanship as the odonatist has to have the basic book as well as this catalogue. Perhaps we are low this morning and over critical. (The furnace fire was out and snow was falling last night when we started to bed at midnight.) We do not mean to be so. It is incomprehensible to an American entomologist driven by our keyed-up American life in an environment of time clocks, telephones, air-mail and automobiles how any man or small group of men can find time to cover the great amount of detailed bibliographic work brought together in the six volumes of the Catalogue.

This work will be followed by supplements giving omissions as these are found and correcting errors. It is a magnificent project and has been capably done. It will be a great stimulus to further work on Chinese insects. It is on good paper and well printed.—C. H. K.

EVOLUTION, by A. FRANKLIN SHULL, pp. i-x and 1–312, 64 figs., 1936. MCGRAW-HILL BOOK COMPANY, INC. Price, $3.00.

It is a great satisfaction to read a book that tells you something, to have facts which have puzzled you assigned their proper places and values in a piece of clear exposition. It has been our observation that too few people even in university circles sit down in a comfortable office with their feet on a desk and really think their problems through from basic assumptions to final conclusions. Too many live a meagre intellectual existence on mental sandwiches, single outstanding facts or small groups of facts of immediate interest, which are bounded on either side by questionable assumptions and conclusions. It has been our further observation that geneticists have to think correctly to survive. Shull is a geneticist, as well as general zoologist. We are glad he took time out to write this particular book.

The volume was written for university undergraduate classes and so lacks the elaborate documentation for which the more mature student might wish. It does not elaborate on the proofs of evolution or the palaeontological and distributional evidence usually piled up in such treatises. It emphasizes the genetic evidence on the processes of species production. After reading the volume one is fairly well convinced that the solution of the problem of evolution, of species formation and a part of species survival or extinction lies in the field of genetics in the study of the behavior of genes and chromosomes. In this book Shull brings together in a simple exposition the various lines of genetic evidence brought to light by workers the world over on the problems of mutation and the survival of mutant forms as "new species."

These studies have even advanced to where such students of the mathematics of genetics as Sewall Wright, R. A. Fisher and J. B. S. Haldane have been able to work out consistent mathematical discussions of its problems. The success of the work in genetics and its expression in logical mathematics suggests that we are at last close to a clear understanding of many of the puzzling problems in evolution. Because of the undergraduate status of his readers the author has avoided the mathematical phases of the work and has produced a volume which can be understood by any thoughtful reader.

Recent field studies have shown that there cannot be the keen competition between species hypothecated by Darwin and even more so by some later admirers of Darwin. Isolation by geographic, climatic or host preference still figures in the picture of species formation but the production of new forms (variation) has simmered down to the behavior of genes and chromosomes.

One problem as such is not discussed in the book, the problem of the decline and extinction of species. This would not appeal to a laboratory zoologist as vividly as it appeals to all students of life in the field. We find virile species on the upgrade in their use of the environment and beside them apparently senile species, widely spread geographically but rare and local in distribution. What has taken from the latter their grip on the environment? We have no concrete evidence, no history of any single species decline but most field men feel that such declines in virility, in ability to meet probably many more than one of the environmental pressures do figure into the final extinction of many lines. Our thinking is too frequently warped by the few instances of the rather sudden extinction, by the advent of man, of otherwise obviously virile species. Probably the greater

part of extinction is not of this nature. Probably the species becomes weakened first by a long hard-luck run of the cards of weakening mutations. In this matter of chance any regular player of cards can remember months on end when cards ran against him and periods of long duration when they fell in his favor. Long lucky runs of mutant cards would merely develop the species to greatest physiological ability. Any slight change in the environment would liquidate a species after a long hard luck run of debilitating or adverse mutations. We regret that the limit of space prevents a more precise use of terms and statement of the case.

The final speculative chapter on the evolution of evolution gave us a thrill. We enjoy any author with courage and imagination sufficient to project his thinking into past events and into the future development of science

We recommend this book to all entomologists who still have a desire to know more definitely what a species of insect may be.—C. H. K.

DIE RASSEN VON PAPILIO MACHAON L., by DR. KARL ELLER. Folio, pp. I–XIV and 1–96, 6 insert maps and graphs, and 16 plates in black and white, 1936. Published by E. J. BRILL, Publisher, Leiden, Holland. Price, unbound, 12 Guilders ($6.60).

This handsome volume is the result of over three years' study by Doctor Karl Eller at the Zoological Institute of the University of Munich and was done under the supervision of Geheimrat Professor Doctor Ludwig Döderlein, to whom it is dedicated. The study is based on the extensive material in the Zoologischen Staatssammlung, München, the Deutschen Entomologischen Museum, Berlin and the great collections in the museums of Hamburg, Tring (Lord Rochschild), London (British Museum), and Barcelona. Thirty-six races of the species *Papilio machaon* L. are described as well as various uniques which may represent other unnamed races. *Machaon*, a yellow and black swallowtail very much like the American *turnus*, extends through the temperate zone from western Europe to Japan and Kamchatka. Its races fall into thirteen groups. Some of the characters defining the numerous races can be produced experimentally by chilling or warming the insect during development. Other characters appear to be genetic. The author terms all the forms geographic races as in all cases he has found specific race characters or groups of characters which differentiate any recognized race from all others.

While such studies as these may appear to an experimentalist needless species splitting it is just such studies on abundant material which are checking field work against recent studies in the genetics laboratory. Out of the two lines of research will come our final picture of species formation and of species evolution. It is the problem of physiological races which at times annoys the research man in applied entomology. Measures which give good control of a pest species in one part of the country may fail on the "same" pest in another area, as really two insects different physiologically are involved.

This is a handsome volume. We wish some method could be devised which would encourage or permit the production of such monographic works in the United States of America. Our high printing and engraving costs completely block such.—C. H. K.

KRITISCH HISTORISCH OVERZICHT DER ACAROLOGIE, by A. C. OUDEMANS. Part III (1805–1850), Vol. A. Acari in general Holothyroidea Reuter, 1909. Mesostigmata Can. 1891. pp. i-xx and 1-430, 179 text figs., 1936. E. J. BRILL, LTD., Publisher, Leyden, Holland. Price, unbound, 15 guilders ($8.25); bound, 17 guilders ($9.35).

This is an encyclopaedic work in nine volumes which reviews all previous literature in acarology. The set, bound, is now quoted at 140 guilders ($77.00). Part I (one volume, 500 pp.) covers acarology from 850 B. C. to 1758 A. D., Part II (one volume, 1100 pp.) covers 1759 to 1804, Part III (seven volumes) covers 1805 to the present. The set is illustrated by the "reproduction of all original illustrations found in the literature."

The author's discussions and comments are in Dutch, original descriptions are quoted in the original language used, which is usually Latin, French, German or English. The arrangement of the material is systematic with first the description, following which are all references chronologically arranged with comments under each which help to clarify that author's use or misuse of the term.

The author, Doctor Anthonie Cornelis Oudemans, of Arnhem, Holland, nearly eighty years old, graduated from the University of Utrecht in 1885 and, excepting the period of the War, has devoted over forty years to an intensive study of mites and ticks. This great review of all the literature of Acarology sums up his life work and detailed knowledge in this field. He has had an almost ideal career in research, early recognition in a difficult and too frequently avoided field, a long period of intense productivity and in later life the time and strength to summarize his life's research by the production of this monumental work. On various parts he has had collaborative help from such leaders in Acarology as Dr. Max Sellnick, Dr. Paul Schulze, Dr. Karl Viets, Dr. Carl Willmann and others. Doctor Oudeman's reputation recommends the work as does the work itself. The work will be a basic necessity to all students of Acarology.

The format is excellent. Large type are used with the lines properly spaced for easy reading. For emphasis black face type, italics and the continental method of spacing letters are used. The work is a credit to the printer.—C. H. K.

THE SCIENTIFIC PRINCIPLES OF PLANT PROTECTION, WITH SPECIAL REFERENCE TO CHEMICAL CONTROL, by HUBERT MARTIN. Second Edition, 1936. Pages i-ix, 379. Edward Arnold & Co., London, Price, 21/- net, or through LONGMANS-GREEN & Co., 114 Fifth Ave., New York, $8.00.

About seventy years ago it was written that certain "Insects Injurious to Vegetation" were to be combatted by "sprinkling with tobacco and red pepper, watering with glauber's salt, infusions of elder, walnut leaves or hops; dusting with ground plaster of Paris, charcoal dust or mixtures of sulphur and Scotch snuff." Contemporaneous with these insect-control experiments Anton de Bary recognized that fungi caused disease in plants and this phase of plant protection was relinquished to a separate group of investigators. Today, applied mycology is the study and treatment of parasitic diseases caused by fungi and bacteria and non-parasitic diseases traced to faulty cultivation and malnutrition. Economic entomology has remained a study of the control of noxious insects (in the widest sense)

The protection of plants from disease or insects involve chemical and physical studies as well as an accurate knowledge of the life-history and habits of the offending organism. The author recognizes that mycologists and entomologists are primarily trained biologists and, therefore, has placed most emphasis on the chemical aspects of plant protection.

The methods employed in plant protection are discussed as preventive and curative. The preventive methods include development of resistant varieties of plants, the use of protective or repellant coverings of chemicals and the employment of such climatic and biologic factors as will render the plant less susceptible to attack. Preventive methods directly affecting the parasite employ the influence of external factors in the activity of the parasite, the destruction of the parasite either on the seed or in the soil prior to planting, and various mechanical means whereby the parasite is trapped or the infection is prevented—usually by treating the sources of infection. Curative methods cause the parasite to be destroyed after it is established on the plant by the application of chemical, mechanical or biological methods.

Ten of the sixteen chapters discuss stomach and contact insecticides, fungicides and combinations of fungicides and insecticides, fumigants, weed killers, seed and soil treatment and the toxic action and chemical constitution of most of these materials. The sulphur, copper, arsenic and fluorine compounds and the organic materials such as nicotine and rotenone are given most prominence. Compatible spreaders, wetters, stickers and emulsifying agents are listed for each material. Trade-names of various insecticide combinations are given in some instances.

Other chapters consider the development of resistant varieties of plants by selection and hybridization as an economical means of plant protection; the influence of fertilizers, soil types, climate and temperature-humidity relationships; the use of biological control methods; the value of traps, trap crops, poison baits, attractants and repellants; and the elimination of wild and alternate hosts and insect carriers as sources of infection.

Although the cost of this book may seem excessive it has an added value as a source of references to original research.—B. J. L.

CHEMIE UND TOXIKOLOGIE DER SCHÄDLINGSBEKÄMPFUNG, by GERHARD PETERS. Sammlung chemischer und chemish-technischer Vorträge, Neue Folge Heft 31, 1936. Pages 1–120, 22 figs. Published by Ferdinand Enke, Hasenbergstiege 3, Stuttgart. Price, 7 marks ($2.87).

This book is an elementary treatise on the toxicology of insecticides. The reviewer would recommend it to students who want to study German and insecticides at the same time. The student will learn the various classes of insecticides, their uses and mode of action and the factors affecting their action. He will also learn something about laboratory methods for the determination of insecticidal value and of certain physical properties of insecticides. He will be impressed by the possibilities of increasing insecticidal action by suitable combinations of insecticides.

The discussion of the action and testing of fumigants is the strongest part of the book, probably because the author has had personal experience with fumigants. He advocates the use of the concentration-exposure time product at a definite temperature and 100 percent kill for expressing the insecticidal value of a fumigant in terms of grams per cubic meter per hour. However, he does not discuss the limitations of this method. William Moore has recently shown that for certain gases and insects the product of concentration and period of exposure is not a constant, but that a constant can be obtained if the concentration is multiplied by a fractional power of the period of exposure. Figure 1, a cartoon illustrating the action of carbon monoxide and hydrocyanic acid on red blood cells and tissues, will be found very amusing.

The author has a very modest opinion of his book, recognizing that it is only a general and incomplete survey of the toxicology of insecticides. It is decidedly not a book for the specialist in this field, because it is neither thorough nor critical and contains no original work nor ideas. The author seems to be afraid of mathematics, particularly statistics, as applied to the evaluation of insecticides. The reviewer agrees with the author that the application of statistics has seldom led to fundamental new knowledge, but on the other hand, the neglect of statistics, particularly in design of experiments, has often led to false or inadequate conclusions. The reviewer has little use for a book on the toxicology of insecticides that disregards variation in susceptibility of insects and that has little to say about other sources of error and the numerical expression of relative effectiveness or toxicity. Notwithstanding its defects, the reviewer is glad to have this book for the information it gives on scientific and common German names of insecticides and insects, and for the references to the German literature on the testing of insecticides.—F. L. C.

ATLAS OF THE SCALE INSECTS OF NORTH AMERICA, by G. F. FERRIS. First series, 136 two-leaf folio folders, 1937. Published by STANFORD UNIVERSITY PRESS, Stanford University, California. Photolith. Price 6 cents each folder as published. The entire atlas 5 cents each folder when ordered in advance. At latter rate the First Series, $6.75.

Each folder of this Atlas in which the author proposes to illustrate all species north of Mexico, deals with one species or one generic description. Each folder is a plate 6½ x 8½ inches with a short descriptive text facing the plate. The large plates carry large drawings which make it possible to bring out clearly the most minute diagnostic characters. In the three folders at hand there is one figure each, of the male and female scale, dorsal and ventral halves of the female without scale cover, dorsal and ventral views of pygidium, antenna and other details. Facing this plate is a short text with the following paragraphs: Synonyms, Hosts and Distribution, Habit, Recognition Characters. When completed this will be a magnificent work. The reproduction of the drawings by the photolith process gives as good results as are obtained in a zinc etching.

Having at one time been in the game of scientific drawing the present writer came to know the majority of scientific artists in this country. Usually they had to go into some other line of work between the ages of forty and fifty years. Few nervous systems can stand such close work in the later years of life. A scientific artist is in a difficult spot. Because of the extreme concentration demanded, a full day's work in the prime of life is only 4 to 6 hours, but the artist has to report at 8 A. M. and remain until 5 P. M. The only solution is either to do sloppy work or to loaf two to four hours each day while on the job. Otherwise

one's health is eventually affected. As far as nervous strain is concerned dictation and conferences are mild work as compared to exact line and stippled drawing. Only regular physical exercise offsets the tension from drawing. A solution would be to engage the artist for the full eight-hour day, demand concentrated work for four to six hours and as part of the day's obligation to the employer two to four hours of physical exercise in a gym or on a golf course with a penalty, if on checking, it was found the artist had attended a movie or card party. A partial solution but under better executive control would be to demand four hours drawing from the artist and four hours at some occupation on the feet, which demanded light physical exercise.

We hope that Professor Ferris' nerves and eyes will see him through this project.—C. H. K.

CULTURE METHODS FOR INVERTEBRATE ANIMALS, A compendium prepared co-operatively by American Zoologists under the direction of a committee from Section F of the American Association for the Advancement of Science, PAUL S. GALTSOFF, FRANK E. LUTZ, PAUL S. WELCH, JAMES G. NEEDHAM, *Chairman*. Pages i-xxxii and 1-590; 85 text figs. 1937. The Comstock Publishing Co., Ithaca, New York. Price, $4.00.

This large octavo volume will probably prove to be one of the most useful books employed in the modern zoological laboratory. During almost the single span of life of the passing generation of biologists zoology has shifted from a morphological to a physiological attack on the problems of animal life. Now living animals have to be kept in the laboratory. Except for a few old acquaintances, the household pests, it is not their natural environment. This situation has placed great limitations on physiological research. Many otherwise soundly planned projects have had to be abandoned and still greater the number never attempted because the problems of successful rearing blocked the way. This shift into physiology has shown biologists what morphology never could have done, how sensitively many organisms are attuned physiologically to their environments, how very diverse environments are from the point of view of the physiologist. This study is beginning to give us a picture of the organic world impossible to have been had from the preceding (though at the time necessary) morphological descriptions of life.

A call was sent out by letter and by published requests for any material whatever on the subject, preferably unpublished methods directly from their devisers. The five hundred pages of condensed information show the response of American biologists and the widespread realization that such a compendium was an immediate necessity. The surprising thing is that so much, in many cases rather precise, information had been buried in laboratory note books. The call heralded a day of resurrection of this information and the beginning of what will probably be a more productive era in the comparative physiology of animals.

As the volume is the first attempt to outline methods of rearing invertebrate animals in general, it is fully a pioneer work. No generalizations are attempted as the information is yet too spotty. The treatment is by individual species arranged taxonomically in their proper groups. In general there are almost as many authors involved as there are species discussed. A long triple-columned list of contributors is given in the front of the book. Few statements of rearing any single species or narrowly limited group cover more than two or three pages. It is thoroughly indexed to species, groups and authors.

Pages 259–517 are devoted to insects. Practically every order has some treatment. The bulk of this information has come from laboratories of applied entomology.

The prophet crying in the wilderness of morphological biology who foresaw the necessity of such a compendium is Professor Needham. His remarkable imagination has always played with future values. He it was who finally got the project under way. In the Preface the work of compilation involved is largely credited to Miss Mary E. Davis, the Committee's Secretary, which is probably a very sound statement.

In the book heavy white paper is used, type are large and lines well spaced and the binding is a very sturdy one in linen. We recommend it to all entomological laboratories.—C. H. K.

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